CITY OF AUSTIN
DEPARTMENT OF PUBLIC WORKS

PROJECT MANUAL

WALNUT CREEK WASTEWATER TREATMENT PLANT PUMPING SYSTEM IMPROVEMENTS

C.I.P. PROJECT NUMBER: 3023.022
CLMC754
IFB 6100

Prepared by

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VOLUME 2 of 4

August 6, 2019

This Project provides insurance to qualified Contractors. Contractors and Subcontractors of any tier shall withhold insurance costs from the bid, thus reducing the bid amount. Please refer to the Supplemental General Conditions (Section 00810) and the Safety Manual for specific information regarding the ROCIP.

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PUMPING SYSTEM IMPROVEMENTS

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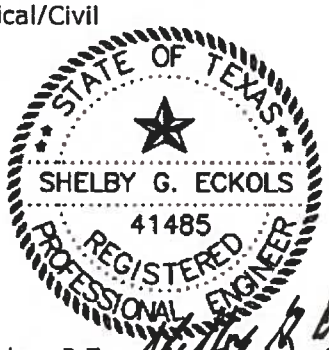

7/31/19

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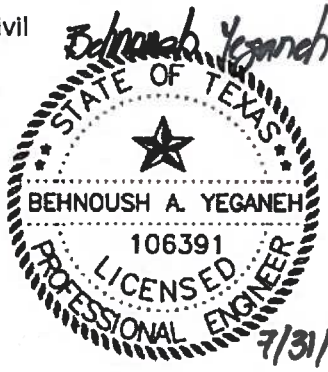

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PROJECT MANUAL

WALNUT CREEK WASTEWATER TREATMENT PLANT
PUMPING SYSTEM IMPROVEMENTS

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07/29/2019

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END

SECTION 02687

TESTING OF INSTALLED PIPING SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Scope: Furnish all labor, materials, tools, and equipment, and perform all operations in connection with testing of installed piping systems and appurtenances.

B. PLANS show pipe sizes, arrangements, working pressures, and test pressures. When PLANS lack such information, minimum test pressures specified in Attachment "B" herein to be used.

1.02 RELATED REQUIREMENTS

A. Piping materials and installation requirement as called for on PLANS or specified elsewhere in this or other TECHNICAL SPECIFICATIONS Sections.

1.03 – 1.11 (NOT USED)

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. All testing to be conducted in the presence of ENGINEER and/or local reviewing authority. A minimum of 24 hours notice is required prior to commencing tests. Length of piping and sections included in tests to meet with approval of ENGINEER.

B. Water for Testing
1. Except for potable water lines, non-potable water may be used for testing.
2. CONTRACTOR is responsible for conveying and ultimate disposal of water used for testing.
3. If potable water is used for testing CONTRACTOR is responsible for metering.
4. Reference the General Conditions for the disposition of costs associated with the purchase of potable water or non-potable water.
5. All costs associated with re-testing to be borne by CONTRACTOR.

C. Furnish all taps, fittings, blind flanges, bulkheads, bracing systems, plugs, and other devices for use in filling, flushing, and testing.

D. Piping installed behind walls, under pavement, or under structures to be tested prior to construction of same.

E. Thrust Blocks: No testing is to be performed until the installation of all thrust blocking has been completed and given sufficient time to cure. Testing is not to begin until a minimum of 36 hours has elapsed since the last thrust block has been poured when utilizing high, early strength concrete for thrust blocking. A minimum of 7 days of thrust block curing is required when utilizing standard concrete.

F. Pipes to be free of dirt, sand, gravel, or other foreign material prior to testing.

G. Protect all valves and appurtenances, in or attached to piping system, from damage due to testing procedures. Any damage resulting from testing procedures to be repaired, and all costs to be borne by CONTRACTOR.

H. When testing absorbent pipe materials, such as concrete, fill the system with water and allow to stand for 24 hours prior to conducting test. Air testing is not to be used with these materials.

I. All fittings, hydrants, and appurtenances to be properly braced and harnessed before the testing commences. Thrust restraining devices which are part of the piping system to be tested at the test pressure.

J. Plug pipe outlets with test plugs, blind flanges or bulkheads. Brace valves, fittings, and plugs securely to prevent blowouts.

K. Furnish adequate venting facilities in system to allow air to escape when filling system for hydrostatic testing.

L. Pressurizing equipment to include a regulator set to avoid over-pressurization of test lines.

M. CONTRACTOR is solely responsible for implementing and adhering to recognized safety procedures to prevent injury to personnel and/or damage to property.

N. For underground lines, backfill to a sufficient depth of cover prior to testing to prevent shifting of the pipe due to pressure.

O. CONTRACTOR to determine groundwater level by installing groundwater gauges in manholes prior to conducting low pressure air tests or testing underground pipes for infiltration and/or exfiltration. Gauges to consist of a rigid section of minimum 1/2-inch diameter pipe, capped and inserted horizontally in manhole wall as near as possible to top of sewer, sealed so as to be watertight. Immediately prior to performance of test, groundwater back pressure to be determined by removing pipe cap, blowing air through pipe into ground to clean pipe, then connecting a clear plastic tube to pipe. Clear plastic tube to be held vertically and measurement of height (in feet) of water over invert of pipe to be taken after water has stopped rising. Upon completion of air test, remove groundwater gauge from wall of manhole and permanently close opening with a nonshrinking, noncorrosive grout.

P. Test pressure is not to exceed rated pressure of valves installed in line.

3.02 HYDROSTATIC TESTING – HIGH HEAD (HH)

A. Test Pressure: Unless otherwise specified in the test schedule herein or the piping schedule on the PLANS, the following pressure restrictions to apply:

1. Test Pressure
   a. 150% of the working pressure at the point of testing; or
   b. 125% of the working pressure at the highest point along the test section.
   c. In the event of a conflict between a. and b. above, the greater value is to apply.
2. For surcharged piping systems, working pressure is defined as the difference in elevation between the lowest point in the piping system and the maximum water surface elevation in the hydraulic structure immediately upstream of the piping system.
3. Test pressure is not to vary by more than plus or minus 5 psi.

B. Duration of Pressure Test: Exposed joints to be tested for not less than 2 hours with no allowable leakage. Covered joints to be tested for a minimum of 6 hours. If leakage at the end of the 6-hour period exceeds the allowable by less than 25%, test to continue for not less than 18 additional hours. For test durations greater than 2 hours, furnish a calibrated pressure recorder to record pressure during test. Reference Paragraph 3.10 for allowable leakage.

C. Pressurization: Each valved section of pipe to be filled with water slowly and the specified test pressure, based on the elevation of the highest point of the line or section under test and corrected to the elevation of the test gauge, to be applied by means of a pump connected to the pipe. Furnish pump, pipe connections, and necessary apparatus, gauge, volumetric measuring device and meters. Furnish necessary labor and assistance for conducting test, all subject to approval by ENGINEER.

D. Air Removal: Before applying the specified test pressure, air to be expelled completely from the pipe, valves, and hydrants. If permanent air vents are not located at all high points, CONTRACTOR to install corporation cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks to be closed and the test pressure applied. At the conclusion of the pressure test, the corporation cocks to be removed and plugged, or left in place at the discretion of the OWNER.

E. Examination: All exposed pipe, fittings, valves, hydrants, and joints to be examined carefully during the test. Any damage or defective pipe, fittings, valves, or hydrants that are discovered following the pressure test to be repaired or replaced with sound material and the test repeated until the leakage is within the specified allowance.

3.03 TESTING GRAVITY FLOW PIPING – (GR)

A. Test gravity flow piping indicated with “GR” in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. Pressure test piping as required for hydrostatic test, with maximum leakage allowance after backfilling.
   5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping for at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water, or allow a new water absorption period of 24 hours for the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
         (1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
            (a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test.

3.04 LOW PRESSURE AIR TEST (LPA)

A. Equipment: Equipment used to meet following minimum requirements.
   1. Pneumatic plugs to have a sealing length equal to or greater than diameter of pipe tested.
   2. Pneumatic plugs to resist internal test pressures without requiring external bracing or blocking.
   3. One of the pneumatic plugs to have inlet tap or other provision for connecting air supply to introduce low pressure air into the line for testing.
   4. All air used shall pass through a single control panel:
      a. From control panel to pneumatic plugs for inflation.
      b. From control panel to a sealed line for introducing low pressure air.
      c. From sealed line to control panel for continuous monitoring of air pressure in sealed line.
   5. Air supply system to have necessary valves and gauges to control rate at which air enters test section and for reading test results.
   6. Pressure gauges to have minimum graduations of 0.1 psi, an accuracy of plus or minus 0.04 psi, and a minimum dial diameter of 3½ inches.

B. Procedure
   1. Isolate test section by installing air-tight plugs. Plug ends of branches, laterals, and wyes which are to be included in test section. Brace all plugs to prevent slippage and blow-out.
   2. CONTRACTOR to carefully observe safety precautions during air testing to prevent injury to personnel from plugs blowing out. No one allowed in manholes during test.
   3. Inflate pneumatic plugs to 25 psig.
   4. Slowly introduce low pressure air into sealed line until pressure reaches test pressure plus 0.5 psig.
      a. Test pressure to be 3.5 psig.
      b. The maximum pressure allowed under any condition in air testing to be 10 psig. The maximum groundwater level for air testing is 13 feet above top of pipe.
   5. Allow a minimum of 2 minutes for temperature and pressure of the air to stabilize. Add air as required to maintain internal pressure specified plus or minus 0.5 psig.
   6. When internal air pressure has stabilized and is at or above test pressure, disconnect air supply and commence test. Utilizing a stopwatch, record period of time required for pressure to drop 1.0 psig from starting pressure. Following table lists minimum test times for various pipe sizes. If time for pressure to decrease 1.0 psig is less than value in table, then system has failed.

Pipe Size	Minimum Test Time	
	Minutes	Seconds
6″	5	40
8″	7	34
10″	9	27
12″	11	20
15″	14	10
18″	17	0
21″	19	50
24″	22	40
27″	25	30
30″	28	20
33″	31	10

For other sizes, consult with ENGINEER.

7. Test may be discontinued when prescribed minimum test time has been reached, even though 1.0 psig pressure drop has not occurred.
8. Release air from pipe slowly and remove plugs at conclusion of test.

3.05 HIGH PRESSURE AIR TESTING (HPA)

A. Purge line to be tested with water or high velocity air as appropriate to system being tested.

B. Unless otherwise specified, perform two-hour pressure test at 150 psig using dry, oil free air. Unless otherwise specified, no leaks will be allowed.

C. Test joints with soapy water solution for leaks.

3.06 EXFILTRATION TESTING (ET)

A. General: Take precautions required to prevent damage to lines and appurtenances being tested. Repair any damage resulting from test at CONTRACTOR's expense. Conduct test in presence of ENGINEER.

B. Preparation: Seal ends of section being tested with water-tight plugs. Fill section with water 24 hours prior to start of test. Vent line during filling so that no air is trapped in line. Leave outlets of stacks, inlets, and service lines exposed and unplugged until after exfiltration test has been made. Outlets terminating below level of test water surface to be temporarily extended upward by installing additional lengths of pipe or by plugging. After completion of satisfactory test, remove lengths of pipe added for test.

C. Duration of Test: Test for at least 2 hours with minimum head of 4 feet measured above top crown, inside pipe at upper end of section being tested.

D. Allowable Leakage: Allowable leakage or exfiltration in any individual section or entire sewer line under construction is defined in Paragraph 3.08. Remove and replace or make approved corrective repairs to any section or line which has leakage or exfiltration that exceeds above amount. Repair any individual leaks that may appear whether or not overall section meets leakage requirements. For this purpose, any steady stream will be considered a leak, while a drip will not. Individual leaks ordinarily will be revealed by looking through sewer with a light while groundwater level is over sewer, during backfill operations, or immediately after water from exfiltration tests is emptied from sewer line. Settlement in backfill during exfiltration tests will be taken and an indication of leakage.

E. Measurement of Leakage: Measure leakage or exfiltration during test period by adding measured quantities of water to maintain water level in test structure. Quantity of water added to maintain water level is amount of leakage or exfiltration.

F. Retest: Sewers failing to meet requirements of leakage test to be tested again for leakage after repair by CONTRACTOR. No sewer will be accepted until leakage is less than allowable.

3.07 INFILTRATION TESTING (IT)

A. General: Infiltration tests will be allowed only when the water table gauges determine the groundwater level to be 2 feet or more above the highest point of the pipeline section being tested. CONTRACTOR to furnish all equipment required for testing. Take precautions to prevent damage to lines and appurtenances being tested. Repair any damage resulting from test at CONTRACTOR's expense. Conduct test in presence of ENGINEER.

B. Preparation: Seal all service laterals, stubs, fittings, and all appurtenances of the upstream end of section being tested with watertight plug(s). Install approved 90-degree, V-notch weir in lower manhole of section to be tested. Weir to be of sufficient size to accommodate flow. Install weir with watertight bulkhead to avoid leakage around bulkhead and weir. Notch of weir to be below centerline of line to be tested and be in the upstream end of manhole or joint of pipe. Pump water from downstream of weir so that water will have a free fall over weir at all times.

C. Duration of Test: Test for 4 hours after downstream sewer is pumped down. Take measurements of head on weir at 30-minute intervals. Volume of infiltration to be calculated by use of standard V-notch weir tables for rate of flow and time of tests.

D. Allowable Leakage: Allowable leakage or infiltration in any individual section or entire sewer line under construction is defined in Paragraph 3.08. Remove and replace or make approved corrective repairs to any section or line which has leakage or infiltration that exceeds above amount. Repair any individual leaks that may appear whether or not overall section meets leakage requirements. For this purpose, any steady stream will be considered a leak, while a drip will not. Individual leaks ordinarily will be revealed by looking through sewer with a light while groundwater level is over sewer, during water tamping operations.

E. Retest: Sewers failing to meet requirements of leakage test will, after repair by CONTRACTOR, be tested again for leakage. No sewer accepted until leakage is less than allowable.

3.08 ALLOWABLE LEAKAGE FOR NONPRESSURE PIPELINES

The allowable leakage (exfiltration or infiltration) for non-pressure pipelines is not to exceed the following:

Type of Pipe	Leakage (gallons per 24 hours per inch of diameter per 1,000 feet of pipe)
Ductile iron - mechanical or push-on joints	10
Polyvinyl chloride, thermal plastic or fiberglass with solvent-cemented joints, or centrifugally cast fiberglass pipe and fittings	10
Concrete with rubber joints	20
Concrete with steel and rubber joints	10
Clay with rubber gasket joints	20
Cast iron soil pipe:	
1. Drains and Vents	0
2. Sewer Laterals	*
All piping inside structures	0

* The same allowable as pipe to which it is connected.

Regardless of the above allowable leakage, any visible leaks detected to be permanently stopped.

3.09 PIPELINE SETTLEMENT TESTING

A. TV Inspection
   1. During infiltration test or after exfiltration test, pipe to be TV inspected for possible settlement. When air testing has been used, run water through pipe to permit meaningful observations. Any pipe settlement which causes ponding of water in pipe is an indication of system failure.
   2. TV inspection required on all sanitary sewers greater than 30 inches in diameter and all sewers installed with curved alignment.

B. Mandrel Testing: All plastic piping materials used for gravity sewers to be subjected to a 95% mandrel test. Mandrel testing to be completed no sooner than four weeks after backfilling has been completed. A Go-No-Go deflection testing mandrel with a minimum of nine runners to be used for testing. Mandrel to be furnished with proving ring. Dimensions of the mandrel for SDR-26 PVC, to be as shown in Attachment "A" to this Section and as required by City of Austin, AWU SPL WW-227 or 227A. For other wall thicknesses, consult ENGINEER. Testing to be as follows:
   1. Completely flush line and clean pipe of debris.
   2. Install pull rope in section to be tested.
   3. Attach pull rope and retrieval rope to mandrel.
   4. Insert mandrel in pipe. Remove slack from pull rope and place tape marker on rope at end of pipe where mandrel will exit. Tape marker to be used to determine mandrel location in line.
   5. Using guide pulleys, pull mandrel through line. Use tape marker to determine location of over-deflected sections.
   6. All pipe sections failing to pass the mandrel to be removed and reinstalled.
   7. Repeat testing until system passes.

3.10 LEAKAGE TESTING FOR PRESSURE PIPELINES

A. Leakage test to be conducted concurrently with hydrostatic pressure tests.

B. Leakage Defined: Leakage is defined as the quantity of water that must be supplied into pipe, or any valved section thereof, to maintain pressure within specified test pressure after air in pipeline has been expelled and pipe has been filled with water and brought to test pressure.

C. Determine rate of leakage at 15-minute intervals by means of volumetric measurement of makeup water added to maintain test pressure. The test to proceed until the rate of leakage has stabilized or is decreasing below an allowable value, for 3 consecutive 15-minute intervals. After this, test pressure to be maintained for at least another 15 minutes.

D. The allowable leakage for pressure pipelines including surcharged gravity lines not to exceed the following in gallons per 24 hours per inch of diameter per mile of pipe:

Type of Pipe	Leakage (gallons per 24 hours per inch of diameter per mile of pipe)
Ductile iron	10
Polyvinyl chloride, thermal plastic or fiberglass with rubber joints	10
Polyvinyl chloride, thermal plastic or fiberglass with solvent-cemented joints, or centrifugally cast fiberglass pipe and fittings	0
Concrete with steel and rubber joints	10
Steel with welded joints	0
Steel with harnessed joints	10
Wrought steel	0
Copper	0
All piping inside structures	0

Regardless of the above allowable leakage, any visible leaks detected to be permanently stopped.

3.11 TESTING OF PLUMBING SYSTEMS

A. Potable Water Lines: Hydrostatically test at 100 psig; maintain pressure for one hour; no leaks allowed.

B. Test vertical soil and waste vents as soon as set. Plug outlets, fill to top of vertical lines, and hold for 24 hours. Make final test after roughing in is complete and before connecting sewer.

C. Perform smoke test on drain, waste and vent (DWV) lines in accordance with the following:
   1. Perform smoke test on DWV lines after all fixtures have been permanently connected and all traps filled with water.

2. Close all windows and doors in the building and turn HVAC system off for the duration of the smoke test.
3. One or more smoke machines to be connected to main building clean out or other suitable connection. Smoke machines to produce a thick penetrating smoke. Smoke produced by chemical mixtures are not acceptable.
4. Add smoke to the system until smoke is visible at vent stacks. Plug vent stacks and continue to add smoke until a pressure of 1-inch water column is produced. Maintain pressure for a minimum of 15 minutes.
5. Visually inspect each connection and fixture for smoke. Any odor or sign of smoke is indication of system failure.
6. Repair all leaks and retest.

3.12 SPECIAL TESTING PROCEDURES

A. Chlorine Gas Piping Systems
1. Clean all portions of the chlorine gas system with a chlorinated solvent such as trichloroethylene. Hydrocarbons or alcohols are not allowed. Cleaning may be accomplished by pulling a cloth saturated with solvent through each length of pipe.
2. Hydrostatically test the system at 300 psig for two hours.
3. Drying: Chlorine gas lines are to be dried prior to introducing gas into the system. Drying to be accomplished by passing steam through the line until all lines are thoroughly heated. While steaming, allow condensate and foreign matter to drain out. Disconnect the steam supply and drain all low spots. While the line is still warm dry air (air with a dew point of -40°F or less) is to be blown through the line until dry. Air drying may take several hours.
4. Gas Testing: After the system is dry, pressurize the system to 150 psig with dry air (-40°F) or nitrogen and test for leaks at joints using soapy water. After testing all joints hold pressure for 30 minutes.
5. Introduce chlorine gas gradually into system and test for leaks at all joints using ammonia water solution.
6. Reference Chlorine Institute Pamphlet No. 6 for any additional testing requirements.

B. LPG or Natural Gas Piping Systems
1. After piping installation is complete, but before installation of gas cocks, test the piping system with LP-gas or air at a pressure of 15 psig for 30 minutes. The source of pressure is to be disconnected from the system and there is to be no loss of pressure on the gauge during the test period.
2. After installation of gas cocks, test the system again with air or LP-gas at 5 psig for 15 minutes. Gas source is to be disconnected and no loss of pressure allowed.
3. If appliances are installed at the same time as the piping system, a final pressure test (including appliance valves) is to be made. The system is to be tested at not more than 14″ water column and not less than 10″ water column for a period of 15 minutes without a drop in pressure.
4. During testing, the piping system is to remain at a constant temperature so that a rise in temperature with a resultant rise in pressure does not mask small leaks.
5. Reference the current edition of the Uniform Plumbing Code for any additional testing requirements.

C. Air Piping Systems
1. Depending on the size of the piping, the system is to be hydrostatically tested or tested with high pressure air. In general, all piping larger than 2″ in size is to be hydrostatically tested. Piping 2″ and smaller may be hydrostatically tested or high pressure air tested (CONTRACTOR's Option).

2. High pressure air systems (systems with a working pressure greater than 15 psig) are to receive a 24-hour stand pressure time test. Test pressure to be 150% of system working pressure, but not less than 150 psig. System to hold pressure for 24-hours with a loss of no greater than 5 psig.
3. Low pressure air systems (systems with a working pressure less than 15 psig) are to receive a 2-hour stand pressure time test at 25 psig. No pressure loss allowed.

D. Vacuum Piping: Test and purge system in accordance with NFPA 56F.

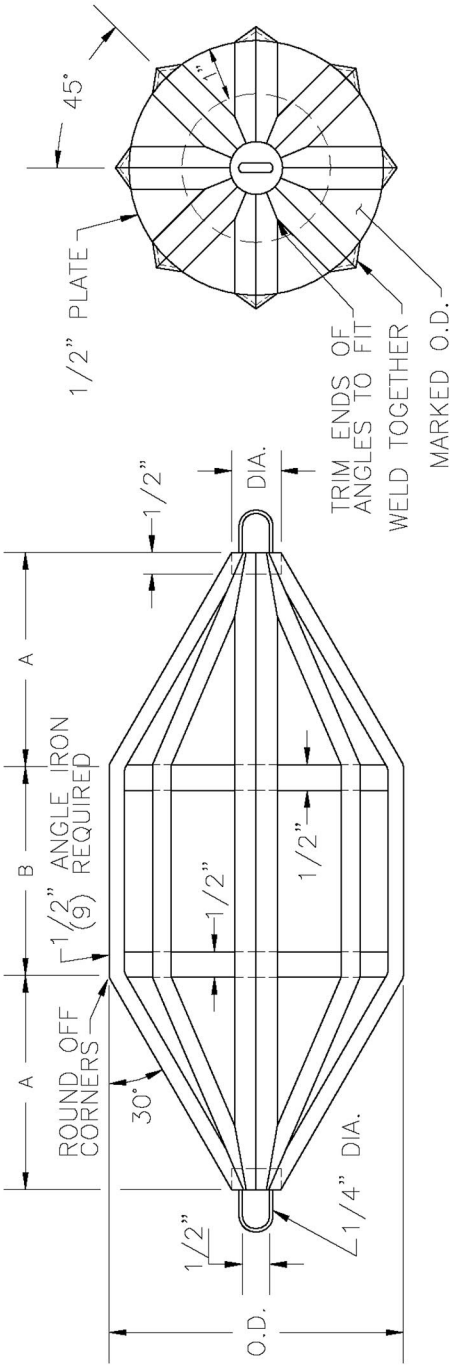
3.13 TESTING PROCEDURES AT INTERFACES WITH EXISTING PIPING OR BOUNDARIES

A. New Piping That Connects to Existing Piping
1. Complete piping up to final closure between existing and new piping.
2. Test new piping per applicable paragraph of this Specification by installing a closure piece to isolate the new section. Test pressure as specified or noted.
3. Complete connection to existing piping. If underground, leave joint exposed.
4. Test piping again, per applicable paragraph of this Specification, to verify the integrity of the completed joint.
   a. Isolate existing piping by installing test plugs or closing valves if they exist. Only isolate piping necessary to verify joint integrity. Test pressure at the interface between new and existing piping to be 110% of the maximum working pressure at the interface. Hold test pressure for one hour. If pressure test fails, maintain pressure at the joint by adding water to the system and visually inspect joint for leaks. If no leaks are visible at the interface, no further testing is required. If leaks are visible, repair and retest.
   b. Only when noted on PLANS or specified elsewhere, place piping in service and visually inspect joint(s). If no leaks are visible at the interface after pressurizing to the maximum working pressure, no further testing is required. If leaks are visible, repair and retest.
5. Coordination with plant operations is required for removing line from service, closing valves and shutdowns.

B. Pipe Testing at the Boundary Between Two Construction Contracts
1. “Installed” piping at the boundary between two construction Contracts is defined as piping that has been installed and tested per Contract Requirements and approved by the ENGINEER.
2. If Connecting Pipe Has Not Been Installed:
   a. Install closure piece (i.e. plug, blind flange, etc.) at the boundary and test per applicable paragraph of this Specification. Test pressure to be as specified.
3. If Pipe at Boundary Is Installed:
   a. Complete piping up to final closure at the boundary.
   b. Test new piping per applicable paragraph of this Specification by installing a closure piece to isolate the new section. Test pressure as specified.
   c. Complete connection at boundary. If underground, leave joint exposed.
   d. Retest piping. Test pressure to be 100% of the maximum working pressure at the boundary. If there are no visible leaks at the interface, then no further testing is required. If leaks are visible at the interface, repair and retest.

3.14 MEASUREMENT AND PAYMENT

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 VIEW

PIPE SIZE (IN.)	A (IN.)	B (IN.)	MANDREL O.D. PVC (SDR-26) ASTM F679 (IN.)	DIA. (IN.)
18	12	12	16.49	2.89
21	14	14	19.44	3.57
24	16	16	21.87	3.73
27	18	18	23.51	4.25

SIDE or TOP VIEW

PIPE SIZE (IN.)	A (IN.)	B (IN.)	MANDREL O.D. PVC (SDR-26) ASTM D3034 (IN.)	DIA. (IN.)
6	4.0	4	5.50	1.00
8	5.3	6	7.37	1.40
10	6.7	6	8.64	1.67
12	8.0	8	10.96	1.95
15	10.0	9	13.42	2.15

DEFLECTION TESTING MANDREL

SCALE:

ATTACHMENT "B"

Service	Size	Required Tests	Test Pressure	Duration	Remarks
Gravity					
A. Storm Sewer	All	Visual	None	N/A	
B. Sanitary Sewer	All	(Exfiltration or Infiltration or Low Pressure Air) + TV + Mandrel	See Text	See Text	
C. Surcharged	All	Hydrostatic	150% of system pressure	2 Hrs. (min.)	
Above Ground					
A. Pump Suction	All	Hydrostatic & Leakage	150% of max. wet well level (25 psi min.)	1 Hr. (min.)	No leaks allowed
B. Pump Discharge	All	Hydrostatic & Leakage	150% of pump shut-off head (100 psi min.)	2 Hrs. (min.)	
C. All Others	All	Hydrostatic & Leakage	150% of system pressure (100 psi min.)	2 Hrs. (min.)	
Underground Pressure Piping	All	Hydrostatic & Leakage	Waterlines: 150 psi Pump discharge: 150% of pump shut-off head (100 psi min.)	2 Hrs. (min.)	
Plumbing (Inside Building)					
A. DWV	All	Low pressure air or hydrostatic smoke	5 psi See Text	24 Hrs. See Text	No leaks allowed
B. Waterlines	All		100 psi	See Text	No leaks allowed
Tank & Fill Drain	All	Hydrostatic & Leakage	150% of tank head	2 Hrs. (min.)	No leaks allowed
Open-Ended Piping	Up to 48″	Hydrostatic & Leakage	25 psi If >48″, consult ENGINEER	1 Hr. (min.)	
Gas Piping					
A. Low Pressure Air	Up to 2″ >2″	High Pressure Air Hydrostatic	25 psi	2 Hrs. (min.)	No leaks allowed
B. High Pressure Air	Up to 2″ >2″	High Pressure Air Hydrostatic	150% of system pressure (150 psi min.)	24 Hrs.	
C. Vacuum	All	High Pressure Air	25 psi	2 Hrs. (min.)	No leaks allowed
D. All Others	Up to 2″ >2″	High Pressure Air Hydrostatic	See Text	See Text	No leaks allowed

END OF SECTION

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SECTION 04090

MASONRY ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Adjustable veneer anchors.
2. Adjustable wall ties.
3. Control joint filler.
4. Column Anchors and Ties.
5. Reinforcing bars.
6. Sheet metal ties.
7. Wall tie screws.
8. Wire joint reinforcement, single Wythe type.
9. Masonry flashing and drainage systems.

1.2 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 Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

1.3 REFERENCES

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

A. ASTM International (ASTM):

1. A 82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
2. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
3. A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
4. A 641 - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
5. A 951 - Standard Specification for Masonry Joint Reinforcement.
6. C 549 - Standard Specification for Perlite Loose Fill Insulation.
7. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.
8. D 2287 - Standard Specification for Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds.

1.4 – 1.5 (NOT USED)

1.6 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, “Submittals”:

B. Shop drawings.

C. Product data.

1.7 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.1– 2.2 (NOT USED)

2.3 MANUFACTURED UNITS

A. Adjustable wall ties: 2-piece zinc coated fabrications, minimum 3/16-inch diameter steel wire formed into hook or pin and eye pieces, capable of restraining compression and tension forces from veneer.

1. Manufacturers: one of the following or equal:

a. Dur-O-Wal, Inc., DA 518 and DA 213.
b. AA Wire Products Co., equivalent product.
c. Wire-Bond, equivalent product.

B. Control joint filler: The key shall be of the width and shape as indicated on the Drawings. In accordance with ASTM D 2000 or ASTM D 2287.

1. Manufacturers: one of the following or equal:

a. AA Wire Products, Inc., AA2000 Blok-Tite.
b. Dur-O-Wall, Rapid Poly-Joint.
c. Vert-A-Joint Co., Vert-A-Joint.

C. Foamed-in-place insulation: as required by Section 07214.

D. Reinforcing bars: in accordance with ASTM A 615, Grade 60, deformed billet steel bars.

Sheet metal ties: minimum [22] gauge corrosion resistant corrugated sheet metal, minimum 7/8 inch wide by 7 inches long, pre-punched for wire ties to wire joint reinforcement.

E. Wire joint reinforcement, single Wythe type: Conforming to ASTM A 951 with ASTM A 82, 9-gauge wire side rails and 9-gauge cross ties, sized to suit application, and galvanized in accordance with ASTM A 153, Class B (minimum 1.5 ounces zinc per square foot.

1. Manufacturers: one of the following or equal:

a. AA Wire Products, Co., AA500 Blok-Lok.
b. Dur-O-Wal, Inc., Ladur-type.
c. Wire-Bond, Ladder Type, Series 200.

F. Single Wythe Concrete Masonry Drainage System: stainless steel drainage strip and vertical mesh sleeve to allow moisture to drain out of single wythe system.

1. Manufacturers: the following or equal:

a. Mortar Net, Inc, Gary IN; #BN120 CMU Drainage System including the following:

1) Drainage Strip: BN 121, 28 ga stainless steel with formed drip edge on the face edge and drainage mesh factory attached.
2) Vertical Mesh Sleeve: BN 122, 7 X 7 X 3/8 inch thick polyester mesh.
3) Sealant as approved by manufacturer.

G. Masonry Drainage and Flashing System: system includes flashing, cavity wall drainage, drip edge, termination bar and weeps.

1. Manufacturers: the following or equal:

a. Mortar Net, Inc, Gary, IN; Total Flash System including the following:

1) Flashing Membrane: Hyload 40 mil polymetric, reinforced, UV stable membrane with DupPant's Elvaloy KEE polymer.
2) Mortar Collection Device/Weep Tabs: Recycled polyester material impregnated with UV protection, biocide to resist mold and flame retardant; woven mesh designed to allow moisture to migrate to the integrated weep tabs; product adhered to flashing membrane; 3/16 inch thick; 10 inches high; 5 ½ feet lengths.
3) Drip edge: 304 stainless steel drip edge pre-attached to flashing membrane with formed drip edge.
4) Adhesive: as recommended by manufacturer.
5) Termination bar: high strength corrosion resistant plastic strip with pre-drilled holes spaced at 6 inches.
6) Screws: as recommended by manufacturer.

PART 3 - EXECUTION

3.1 (NOT USED)

3.2 (NOT USED)

3.3 INSTALLATION

A. Install products as specified in Section 04220 and in accordance with Manufacturer's installation instructions.

3.4 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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

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SECTION 04100

MORTAR AND MASONRY GROUT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Mortar and masonry grout.

1.2 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.

1.3 REFERENCES

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

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

1. C 144 - Standard Specification for Aggregate for Masonry Mortar.
2. C 150 - Standard Specification for Portland Cement.
3. C 207 - Standard Specification for Hydrated Lime for Masonry Purposes.
4. C 270 - Standard Specification for Mortar for Unit Masonry.
5. C 404 - Standard Specification for Aggregates for Masonry Grout.
6. C 476 - Standard Specification for Grout for Masonry.
7. C 780 - Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry.

B. International Conference of Building Officials (ICBO):

1. International Building Code (IBC) Standards:

    a. ASTM C 140 - 02C – Methods of Sampling and Testing Concrete Masonry Units.
    b. ASTM C 1019 – 03, Test Methods for Sampling and Testing Grout.

C. The Masonry Society:

1. TMS MSJC - Building Code for Masonry Structures (ACI 530/ASCE 5/TMS 402), Specification for Masonry Structures (ACI 530.1/ASCE 6/TMS 602) and Commentaries.

1.4 DEFINITIONS

A. Alkali: Sum of sodium oxide and potassium oxide calculated as sodium oxide.

1.5 DESIGN AND PERFORMANCE CRITERIA

A. Performance Requirements

1. Mortar for masonry shall be by proportion, in accordance with ASTM C270 Type “S”, except all below-grade mortar shall be Type “M”.
2. Grout for hollow masonry units shall be by proportion in accordance with ASTM C476 and shall be normal-weight pea gravel concrete.
3. Mortar color shall be submitted and determined by ENGINEER.

1.6 SUBMITTALS

A. Furnish the following in accordance with Specifications Section 01300, “Submittals”:

1. Product Data.

2. Shop Drawings.

3. Samples: Include mortar color samples.

4. Design Data: Design Mixes for mortar and grout.

B. Submit all required LEED documentation for mandatory and desirable credits noted in paragraph 1.05 per the submittal requirements outlined in Section 01352.

1. Materials Resources Certificates:

a. Certify source for local and regional materials and distance from Project site.

2. Indoor Air Quality Certificates:

a. Certify volatile organic compound content for each interior adhesive and sealant and related primer.

1.7 QUALITY ASSURANCE

Materials for Mortar and Grout: Do not change source of materials which will affect the appearance of finished work after the work has started unless acceptable to ENGINEER.

1.8 (NOT USED)

1.9 PROJECT CONDITIONS

A. Environmental Requirements:

1. Cold Weather Requirements:

a. In accordance with the applicable building code.
b. Provide adequate equipment for heating mortar and grout materials when air temperature is below 40 degrees Fahrenheit. Temperatures of separate materials, including water, shall not exceed 140 degrees Fahrenheit when placed in mixer. Maintain mortar temperature on boards above freezing.

2. Hot Weather Requirements: Wet mortar board before loading and cover mortar to retard drying when not being used.

1.10-1.11 (NOT USED)

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement: In accordance with ASTM C 150, Type II, low alkali, containing maximum 0.6 percent total alkali.

B. Hydrated Lime: In accordance with ASTM C 207, Type S.

C. Aggregate:

1. Fine Aggregate: In accordance with ASTM C 144, sand.
2. Coarse Aggregate: In accordance with ASTM C 404, coarse, size Number 8.

D. Admixtures:

1. Color Admixture: Type containing maximum 15 percent lime proof, inorganic compounds, unless recommended otherwise by manufacturer, and maximum 3 percent carbon black by weight of cement, with:

a. Factory blend for full color saturation of mortar joint.
b. Packaging for unitized jobsite mixing at ratio of 1 unit of color per sack of portland cement.

2. Grout Admixture:

a. Manufacturers: One of the following or equal:

1) Sika Corp., Sika Grout Aid, Type II.
2) Concrete Emulsions, Grout Aid GA-II.

3. Mortar Water Repellent Admixture:

    a. Manufacturers: must be the same manufacturer as CMU integral water repellant as specified in Section 04220, from one of the following or equal:

        1) W.R. Grace, Dry Block Mortar.
        2) Sika Corp., Sikaproof 85.
        3) Master Builders Corp., Omicron Mortar Proofing.

4. Other Admixtures: Prohibited, unless accepted by the ENGINEER.

E. Water: Clean, clear, potable, free of oil, soluble salts, chemicals, and other deleterious substances.

2.2 MIXES

A. Mortar Mixes:

1. Mortar Mixing:

    a. Mix on jobsite in accordance with ASTM C 270, Type S, to meet performance requirements.
    b. Mix in mechanical mixer and only in quantities needed for immediate use.
    c. Mix for minimum 3 minutes, and maximum of 5 minutes after materials have been added to mixer.

2. Measurement for ingredients for mortar shall be either by volume or weight. Measure by one of the following methods:

    a. Measurement by Volume: If ingredients are measured by volume, measurement of sand shall be accomplished by the use of a container of known capacity.
    b. Shovel count.

3. Water shall be mixed with the dry ingredients in sufficient amount to provide a workable mixture which will adhere to the vertical surfaces of masonry units:

    a. Use no mortar which has been standing for more than 1 hour after being mixed.
    b. Whenever 90 minutes has elapsed since last batch was mixed, completely empty mixer drum of materials and wash down before placing next batch of materials.

B. Grout Mixes:

1. Grout Mixing:

    a. Mix on jobsite in accordance with ASTM C 476 or in transit mixer to meet performance requirements with 8 to 10 inch slump.
    b. Use within 90 minutes after addition of mixing water.
    c. Mix for minimum of 5 minutes after ingredients are added and until uniform mix is attained. Grout shall have sufficient water added to produce pouring consistency without segregation.

2. Mix grout with coarse aggregate for cavity walls with horizontal dimension of 2 inches or more, and hollow cell masonry units with minimum 4-inch cell dimensions in both horizontal directions.

2.3 NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as specified in Section 04220.

3.2 FIELD QUALITY CONTROL

A. Testing of Grout and Mortar:

1. Grout and mortar mix proportions, as prescribed by the ASTM standards identified in 1.05.B. above, shall be verified in the presence of the ENGINEER, using standardized volume containers for all materials, including a box for sand. The mix volumes shall be verified daily or as determined by ENGINEER.

3.3 ADJUSTING

A. Repair of Defective Masonry:

1. Remove and replace or repair defective work.
2. Do not patch, repair, or cover defective work without inspection by the ENGINEER.
3. Provide repairs having strength equal to or greater than specified for areas involved.

3.04 - 3.10 (NOT USED)

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

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SECTION 04220

CONCRETE MASONRY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Concrete masonry units and accessories.

1.2 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.

1.3 REFERENCES

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

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

1. C 90 - Standard Specification for Loadbearing Concrete Masonry Units.
2. C 140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
3. C 426 - Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units.

1.4 DEFINITIONS

A. Standard Level of Quality: High quality, but conventional, nearly free of chips, cracks or other imperfections detracting from appearance when discernible and identified from distance of 20 feet under diffused lighting. When level of quality is not specified, Standard Level of Quality shall be assumed.

1.5 (NOT USED)

1.6 SUBMITTALS

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

B. Product Data: Submit manufacturer's product data for block.

C. Samples: Include a sufficient quantity samples of stretcher units to illustrate color range.

D. Test Reports:

1. Compressive strength.
2. Linear shrinkage.
3. Moisture content as a percentage of total absorbtion.
4. Total absorbtion.
5. Unit weight.

E. Submit all required LEED documentation for mandatory and desirable credits noted in paragraph 0 per the submittal requirements outlined in Section 01352.

1. Materials Resources Certificates:

a. Certify recycled material content for recycled content products.
b. Certify source for local and regional materials and distance from Project site.

2. Indoor Air Quality Certificates:

a. Certify volatile organic compound content for each interior adhesive and sealant and related primer.

1.7 QUALITY ASSURANCE

A. Mock-Up:

1. Prior to starting construction of masonry, construct minimum 4 foot square mock-up.
2. Use accepted materials, containing each different kind and color of concrete masonry units and water repellant to illustrate wall design.
3. When not accepted, construct another mock-up.
4. When accepted, mock-up will be standard of comparison for remainder of masonry work.
5. Upon completion of Project, dispose of mock-ups in legal manner at offsite location in accordance with Section 01505.

B. Pre-Installation Conference: Conduct as specified in Section 01200.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Transport and handle concrete masonry units as required to prevent discoloration, chipping, and breakage.

B. Store masonry units off the ground in a dry location, covered and protected from absorbing moisture. Locate storage piles, stacks, and bins to protect materials from heavy traffic.

C. Remove chipped, cracked, and otherwise defective units from jobsite upon discovery.

1.9 PROJECT CONDITIONS

A. Environmental Requirements:

1. Cold Weather Requirements:

a. In accordance with applicable building code, provide adequate equipment for heating masonry materials when air temperature is below 40 degrees Fahrenheit.

2. Hot Weather Requirements:

a. In accordance with applicable building code, when ambient air temperature exceeds 100 degrees Fahrenheit, or when ambient air temperature exceeds 90 degrees Fahrenheit and wind velocity is greater than 8 miles per hour, implement hot weather protection procedures.
b. Wet mortar board before loading and cover mortar to retard drying when not being used.
c. Do not spread mortar beds more than 48 inches ahead of placing masonry units.
d. Place masonry units within one minute of spreading mortar.

B. Sequencing and Scheduling:

1. Order concrete masonry units well before start of installation to ensure adequate time for manufacturing and minimum 28 days for curing and drying before start of installation. Protect from weather after curing period to avoid moisture increase.

1.10 - 1.11 (NOT USED)

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Hollow Load Bearing Concrete Masonry Units:

1. Class: Class 3 in accordance with ASTM C 90, Standard Level of Quality with minimum compressive strength of 1,900 pounds per square inch.
2. Surface Texture: Standard and split face with dense faces suitable for painting where scheduled to be painted.
3. Color:

a. Standard: Integral, Natural gray of concrete.
b. Split Face: color to be selected from manufacturer’s full range of colors.

4. Typical Size: 8 or 12 inches wide by 8 inches high by 16 inches long, unless otherwise indicated on the Drawings, or other sizes as needed to minimize cutting.
5. Special Sizes and Shapes: As required for window and door openings, bond beams, piers, lintels, control joints, and other special applications to minimize cutting.

6. Recycled Content: Min. 50 percent Pre-Consumer.
7. Manufacturers: One of the following or equal:

    a. Featherlite Corp.

B. Anchor Bolts: As specified in Section 05120.

C. Steel Reinforcement: As specified in Section 04090.

D. Wall Ties: As specified in Section 04090.

E. Wire Joint Reinforcement: As specified in Section 04090.

F. Foamed-in-place Insulation: As specified in Section 07214.

2.2 ACCESSORIES

A. Control joint: As specified in 04090.

B. Integral water repellant for all masonry units (added during manufacture) and in all mortar (added during mortar mixing) shall be "Dry-Block II Admixture" by W.R. Grace; Krete Industries, or approved equal, liquid polymeric admixture at rates as recommended by the manufacturer. The same product shall be used in masonry units and in mortar.

C. Water Repellant: As specified in Section 07190.

D. Flashing for single-wythe CMU exterior: As specified in 04090

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection:

1. Protect adjacent construction with appropriate means from mortar droppings and other effects of laying of concrete masonry units.

B. Surface Preparation:

1. Thoroughly clean foundations of laitance, grease, oil, mud, dirt, mortar droppings, and other matter that will reduce bond.

3.2 INSTALLATION

A. Forms and Shores:

1. Where Required, Construct Forms to the Shapes indicated on the Drawings:

   a. Construct forms sufficiently rigid to prevent deflection which may result in cracking or other damage to supported masonry and sufficiently tight to prevent leakage of mortar and grout.
   b. Do not remove supporting forms or shores until the supported masonry has acquired sufficient strength to support safely its weight and any construction loads to which it may be subjected.

      1) Wait at least 24 hours after grouting masonry columns or walls before applying uniform loads.

2. Wait at least 72 hours before applying concentrated loads.

B. Concrete Masonry Units:

1. Provide Standard Level of Quality.
2. Lay concrete masonry units dry.
3. Lay units in uniform and true courses, level, plumb, and without projections or offset of adjacent units.
4. Lay units to preserve unobstructed vertical continuity of cells to be filled with grout or insulation.
5. Align vertical cells to be filled with grout to maintain clear, unobstructed continuous vertical cell measuring not less than 2 by 3 inches.
6. Place mortar with full coverage of joints at webs of all cells and face shells.
7. Butter vertical head joints for thickness equal to face shell thickness of units, and shove joints tightly together so that mortar bonds to both masonry units.
8. Solidly fill joints from face of units to inside face of cells.
9. Lay units to desired height with joints of uniform thickness.
10. Bond shall be plumb throughout.
11. Lay units to avoid formation of cracks when units are placed. Keep cells of units as free of mortar as possible as masonry wall height increases.
12. When positions of units shift after mortar has stiffened, bond is broken, or cracks are formed, relay units in new mortar.
13. Remove mortar, mortar droppings, debris, and other obstructions and materials from inside of cell walls to receive grout or insulation.
14. Seal cleanouts after inspection and before grouting or placing insulation.

C. Bond Pattern:

1. Lay concrete masonry units in running bond pattern, unless otherwise indicated on the Drawings.

D. Foamed-In-Place Insulation:

1. Where indicated on the Drawings, fill concrete masonry unit cells of building exterior walls that are not to be filled with reinforcing and grout, with foamed-in-place insulation.
2. Fill in accordance with Section 07214.

E. Mortar Joints:

1. Make joints straight, clean, smooth, and uniform in thickness.
2. Tool exposed joints, slightly concave. Strike concealed joints flush.
3. Make vertical and horizontal joints 3/8 inch thick.
4. Where fresh masonry joins totally or partially set masonry, clean and roughen set masonry before laying new units.

F. Wire Joint Reinforcement:

1. Lap splice longitudinal wire joint reinforcement minimum 75 wire diameters.
2. Place longitudinal wires in approximate centers of mortar beds with minimum 5/8-inch mortar cover on exposed faces.
3. Provide intersecting masonry walls with prefabricated wire joint reinforcement tees.
4. Rake intersecting joints 1/2 inch and caulk joints.

G. Grouting and Reinforcement:

1. Where horizontal and vertical bars are spliced, and adjacent lap splices are separated by more than 3 inches, the lap splice length shall be 72 bar diameters. Where adjacent lap splices are separated by 3 inches or less, the lap splice length shall be increased by 1.3 times or the lap splices shall be staggered at least 24 bar diameters with no increase in length.
2. Hold vertical reinforcing bars in position at top and bottom and at intervals not exceeding 200 bar diameters. Use steel wire bar positioners to position bars. Tie reinforcing bars to dowels with wire ties.
3. Obtain acceptance of reinforcement placement before grouting.
4. Unless specified on drawings, fill spaces and cells containing reinforcing bars solidly with grout.

    a. Low-Lift Grouting:

        1) Hollow unit masonry to be grouted by the low lift method shall be constructed and grouted in lifts not exceeding 5 feet.
        2) Slushing with mortar will not be permitted.

    b. High-Lift Grouting:

        1) If grouting is accomplished by the high-lift method, double wythe masonry shall be allowed to cure at least 72 hours.
        2) Hollow unit masonry shall be allowed to cure at least 24 hours before grouting.
        3) In double wythe construction, vertical grout barriers shall be built across the grout space to the height of the grout lift. Grout barriers shall not be spaced more than 30 feet apart.
        4) Grout shall be placed in lifts not to exceed 6 feet in depth.
        5) Each lift shall be allowed to set for 10 minutes after initial consolidation of grout before successive lift is placed.
        6) The full height of each section of wall shall be grouted in one day.

5. Grout in cells shall have full contact with surface of concrete footings.
6. When grouting stops for one hour or longer, form horizontal construction joints by stopping grout placement 1-1/2 inches below top of uppermost unit containing grout.
7. After placement, consolidate grout using mechanical immersion vibrators designed for consolidating grout.
8. Placement:

    a. Use a hand bucket, concrete hopper, or grout pump.
    b. Place grout in final position within 1-1/2 hours after mixing. Place grout so as to completely fill the grout spaces without segregation of the aggregates.
    c. Do not insert vibrators into lower grout placements that are in a semi-solidified state.

H. Bond Beams:

1. Place horizontal reinforcement and solidly grout bond beam units in place.
2. Provide wire mesh at openings in bottom of bond beams to support grout where walls are not grouted solid.

I. Cutting Concrete Masonry Units:

1. When possible, use full units of the proper size in lieu of cut units. Cut units as required to form chases, openings, for anchorage, and for other appurtenances.
2. Cut and fit units with power-driven carborundum or diamond disc blade saw.

J. Control Joints:

1. Provide in masonry walls at locations indicated on the Drawings.
2. Make full height and continuous in appearance.
3. Run bond beams and bond beam reinforcing bars continuously through control joints.
4. Insert control joint filler in joints as wall is constructed.
5. Apply sealant as specified in Section 07900.

K. Openings and Lintels:

1. Place horizontal reinforcement in fully grouted bond beam units.
2. Use lintel block units where underside of lintel will be exposed.
3. Provide minimum of 8-inch bearing at each end of lintel.
4. Embed reinforcing bars minimum 24 inches or 48 bar diameters, whichever is longer, into wall past edges of openings or as indicated on the Drawings:

    a. At corners, provide 90-degree bend with equivalent total embedment.

L. Steel Door Frames:

1. Anchor and fully grout jambs and head of steel door frames connected to concrete unit masonry.
2. Fill frames with grout as each 2 feet of concrete unit masonry is laid.

M. Bearing Plates:

1. Provide minimum of 12 inches of grouted concrete unit masonry below steel bearing plates and beams bearing on masonry walls.

N. Anchor Bolts:

1. Hold anchor bolts in place with template during grouting to assure precise alignment.
2. Do not cut or ream members being anchored or use other means to accommodate misaligned anchor bolts in roof deck support angles.
3. Provide minimum 6-inch wide grouted concrete unit masonry entirely around anchor bolts and other attachment devices.

O. Wall Ties:

1. In composite or cavity 2 wythe walls, bond masonry units together by embedding wall ties with a minimum of one per 4-1/2 square feet of wall area.
2. Stagger ties in alternate courses, with maximum vertical distance between ties at 18 inches on center and maximum horizontal distance between ties at 36 inches on center.

P. Enclosures:

1. Where concrete masonry units enclose conduit, pipes, stacks, ducts, and similar items, construct chases, cavities, and similar spaces as required, whether or not such spaces are indicated on the Drawings.
2. Point openings around flush mounted electrical outlet boxes with mortar, including flush joints above boxes.
3. Do not cover enclosures until inspected and when appropriate, tested.

Q. Other Embedded Items:

1. Build in wall plugs, accessories, flashings, pipe sleeves, and other items required to be built-in as the masonry work progresses.

R. Patching:

1. Patch exposed concrete masonry units at completion of the Work and in such manner that patching will be indistinguishable from similar surroundings and adjoining construction.

S. Water Curing:

1. Protect concrete masonry units from drying too rapidly by frequently fogging or sprinkling so walls will always be visibly damp for minimum 3 days.

T. Miscellaneous:

1. Build in required items, such as anchors, flashings, sleeves, frames, structural steel, lintels, anchor bolts, and metal fabrications, as required for complete installation.

U. External Water Repellent:

1. Apply according to manufacturer’s recommendations.

V. Grouting Equipment:

1. Grout Pumps:

    a. Do not pump grout through aluminum tubes.
    b. Operate pumps to produce a continuous stream of grout without air pockets.

c. Upon completion of each days pumping, eject grout from pipeline without contamination or segregation of the grout:

1) Remove waste materials and debris from the equipment.
2) Dispose of waste materials, debris, and all flushing water outside the masonry.

2. Vibrators:

a. Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the grout.
b. Maintain at least 1 spare vibrator, at the site at all times.
c. Apply vibrators at uniformly spaced points not further apart than the visible effectiveness of the machine.
d. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.

3.3 CONSTRUCTION

A. Site Tolerances: Lay masonry plumb, true to line, and with courses level. Keep bond pattern plumb throughout. Lay masonry within the following tolerances:

1. Maximum variation from the plumb in the lines and surfaces of columns, walls, and in the flutes and surfaces of fluted or split faced blocks:

a. In Adjacent Masonry Units: 1/8 inch.
b. In 10 Feet: 1/4 inch.
c. In Any Story or 20 Feet maximum: 3/8 inch.
d. In 40 Feet or More: 1/2 inch.

2. Maximum variations from the plumb for external corners, expansion joints, and other conspicuous lines:

a. In Any Story or 20 Feet Maximum: 1/4 inch.
b. In 40 Feet or More: 1/2 inch.

3. Maximum variations from the level or grades indicated on the Drawings for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines:

a. In Any Bay or 20 Feet Maximum: 1/4 inch.
b. In 40 Feet or more: 1/2 inch.

4. Maximum variations of the linear building lines from established position in plan and related portion of columns, walls, and partitions:

a. In Any Bay or 20 Feet Maximum: 1/2 inch.
b. In 40 Feet or More: 3/4 inch.

5. Maximum variation in cross sectional dimensions of columns and in thickness of walls:

a. Minus: 1/4 inch.
b. Plus: 1/2 inch.

3.4 FIELD QUALITY CONTROL

A. Site Tests:

1. OWNER will have tests performed by an independent laboratory.
2. Have minimum 3 concrete masonry units of each type proposed for Project tested in accordance with ASTM C 90, C 140, and C 426 to verify conformance to Specifications.
3. Tests shall include compressive strength, linear shrinkage, moisture content as percent of total absorption, total absorption, and unit weight.

B. Special Inspection:

1. OWNER will employ a qualified masonry special inspector for continuous special inspection of the masonry work. Acceptance by a State or municipality having a program of examining and certifying masonry inspectors will be considered adequate qualifications. The masonry inspector shall be at the site during all masonry construction and perform the following duties:

    a. Review Drawings and Specifications and meet with the CONTRACTOR to discuss requirements before work commences.
    b. Before masonry work commences, CONTRACTOR and the CONTRACTOR's Quality Control Representative shall attend meeting with ENGINEER to review the requirements for surveillance and quality control of the masonry work.
    c. Check brand and type of cement, lime (if used), and source of sand.
    d. Verify that foundation is clean, rough, and ready to receive units.
    e. Check reinforcing steel dowels for correct location, straightness, proper alignment, spacing, size, and length.
    f. Observe field proportioning of mortar. Visually check aggregate to determine uniformity of grading, cleanliness, and moisture.
    g. Verify that joints are full of mortar and kept tight during work. Inspect grout cells to verify that fins will not interfere with grouting. Verify that masons keep grout cells clean of mortar droppings and inspect to determine compliance.
    h. Continuously observe placing of grout.
    i. Perform or supervise performance of required sampling and testing.

2. Keep complete record of inspections. Report daily to the Building Official, CONTRACTOR's Quality Control Representative, ENGINEER, and OWNER the progress of the masonry inspection.

3.5 CLEANING

A. Exercise extreme care to prevent mortar splotches.

B. Do not attach construction supports to concrete masonry walls.

C. Wash off concrete scum and grout spills before scum and grout set.

D. Remove grout stains from walls.

E. Clean exposed masonry. Remove scaffolding and equipment. Dispose of debris, refuse, and surplus material offsite legally.

F. Remove efflorescence on exposed surfaces with commercially prepared cleaning solution acceptable to masonry unit manufacturer:

1. Apply cleaning solution in accordance with cleaning solution manufacturer's printed instructions.
2. Do not use muriatic acid as cleaning solution.
3. Do not use high pressure cleaning equipment.

3.6 PROTECTION

A. Provide temporary protection for exposed masonry corners subject to damage.

B. Bracing:

1. Unless wall is adequately supported by permanent supporting elements so wall will not overturn or collapse, adequately brace masonry walls over 8 feet in height to prevent overturning and to prevent collapse.
2. Keep bracing in place until permanent supporting elements of structure are in place.

C. Limited Access Zone:

1. Establish limited access zone prior to start of masonry wall construction.
2. Zone shall be immediately adjacent to wall and equal to height of wall to be constructed plus 4 feet by entire length of wall on unscaffolded side of wall.
3. Limit access to zone to workers actively engaged in constructing wall. Do not permit other persons to enter zone.
4. Keep zone in place until wall is adequately supported or braced by permanent supporting elements to prevent overturning and collapse.

3.07 - 3.10 (NOT USED)

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

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SECTION 05120

STRUCTURAL STEEL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Structural steel.
2. Grout.

1.2 DEFINITIONS

A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

1.3 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, “Submittals”:

B. Product Data: For each type of product.

C. Shop Drawings: Show fabrication of structural-steel components.

1.4 INFORMATIONAL SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, “Submittals”:

B. Welding certificates.

C. Mill test reports for structural steel, including chemical and physical properties.

D. Source quality-control reports.

1.5 QUALITY ASSURANCE

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

B. Comply with applicable provisions of the following specifications and documents:

1. AISC 303.
2. AISC 360.
3. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

PART 2 - PRODUCTS

2.1 STRUCTURAL-STEEL MATERIALS

A. W-Shapes: ASTM A 992/A 992M.

B. Channels, Angles, S-Shapes: ASTM A 36/A 36M.

C. Plate and Bar: ASTM A 36/A 36M.

D. Cold-Formed Hollow Structural Sections: ASTM A 500/A 500M, Grade B, structural tubing.

E. Steel Pipe: ASTM A 53/A 53M, Type E or Type S, Grade B.

F. Welding Electrodes: Comply with AWS requirements.

2.2 BOLTS, CONNECTORS, AND ANCHORS

A. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C, heavy-hex carbon-steel nuts; and ASTM F 436, Type 1, hardened carbon-steel washers; all with plain finish.

B. Threaded Rods: ASTM A 36/A 36M.

1. Finish: Hot-dip zinc coating, ASTM A 153/A 153M, Class C.

2.3 PRIMER

A. Primer: Fabricator's standard lead- and chromate-free, non-asphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat.

2.4 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

2.5 FABRICATION

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," and to AISC 360.

2.6 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

2.7 SHOP PRIMING

A. Shop prime steel surfaces except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
2. Surfaces to be field welded.
3. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
4. Galvanized surfaces.
5. Surfaces enclosed in interior construction.

B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:

1. SSPC-SP 2, "Hand Tool Cleaning."
2. SSPC-SP 3, "Power Tool Cleaning."

C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedment elements for compliance with requirements.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

B. Baseplates and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.

1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Weld plate washers to top of baseplate.
3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

C. Maintain erection tolerances of structural steel within AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

3.3 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Bolted Connections: Inspect bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

C. Welded Connections: Visually inspect field welds according to AWS D1.1/D1.1M.

1. In addition to visual inspection, test and inspect field welds according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:

a. Liquid Penetrant Inspection: ASTM E 165.
b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.

c. Ultrasonic Inspection: ASTM E 164.
d. Radiographic Inspection: ASTM E 94.

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SECTION 05310

STEEL DECK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Roof deck.

1.2 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, “Submittals”:

B. Product Data: For each type of deck, accessory, and product indicated.

C. Shop Drawings:

1. Include layout and types of deck panels, anchorage details, reinforcing channels, pans, cut deck openings, special jointing, accessories, and attachments to other construction.

D. Welding certificates.

E. Product certificates.

F. Evaluation reports.

1.3 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.3, "Structural Welding Code - Sheet Steel."

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.

B. Stack steel deck on platforms or pallets and slope to provide drainage. Protect with a waterproof covering and ventilate to avoid condensation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AISI Specifications: Comply with calculated structural characteristics of steel deck according to AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."

2.2 ROOF DECK

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

1. CMC Joist & Deck.
2. Consolidated Systems, Inc.; Metal Dek Group.
3. Nucor Corp.; Vulcraft Group.
4. Verco Manufacturing Co.
5. Wheeling Corrugating Company; Div. of Wheeling-Pittsburgh Steel Corporation.

B. Roof Deck: Fabricate panels, without top-flange stiffening grooves, to comply with "SDI Specifications and Commentary for Steel Roof Deck," in SDI Publication No. 31, and with the following:

1. Galvanized-Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33, G60 zinc coating.
2. Deck Profile: Type IR, intermediate rib.
3. Profile Depth: 1-1/2 inches.
4. Design Uncoated-Steel Thickness: 0.0358 inch.
5. Span Condition: Triple span or more.
6. Side Laps: Overlapped.

2.3 ACCESSORIES

A. General: Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.

B. Mechanical Fasteners: Corrosion-resistant, low-velocity, power-actuated or pneumatically driven carbon-steel fasteners; or self-drilling, self-threading screws.

C. Side-Lap Fasteners: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, No. 10 minimum diameter.

D. Flexible Closure Strips: Vulcanized, closed-cell, synthetic rubber.

E. Miscellaneous Sheet Metal Deck Accessories: Steel sheet, minimum yield strength of 33,000 psi, not less than 0.0359-inch design uncoated thickness, of same material and finish as deck; of profile indicated or required for application.

F. Galvanizing Repair Paint: ASTM A 780.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine supporting frame and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install deck panels and accessories according to applicable specifications and commentary in SDI Publication No. 31, manufacturer's written instructions, and requirements in this Section.

B. Place deck panels on supporting frame and adjust to final position with ends accurately aligned and bearing on supporting frame before being permanently fastened. Do not stretch or contract side-lap interlocks.

C. Place deck panels flat and square and fasten to supporting frame without warp or deflection.

D. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to deck.

E. Provide additional reinforcement and closure pieces at openings as required for strength, continuity of deck, and support of other work.

F. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work.

G. Mechanical fasteners may be used in lieu of welding to fasten deck. Locate mechanical fasteners and install according to deck manufacturer's written instructions.

H. Miscellaneous Roof-Deck Accessories: Install ridge and valley plates, finish strips, end closures, and reinforcing channels according to deck manufacturer's written instructions. Weld or mechanically fasten to substrate to provide a complete deck installation.

1. Weld cover plates at changes in direction of roof-deck panels unless otherwise indicated.

3.3 ROOF-DECK INSTALLATION

A. Fasten roof-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated or arc seam welds with an equal perimeter that is not less than 1-1/2 inches long, and as follows:

1. Weld Diameter: 5/8-inch, nominal.
2. Weld Spacing: Weld edge and interior ribs of deck units with a minimum of two welds per deck unit at each support. Space welds 12 inches apart in the field of roof and 6 inches apart in roof corners and perimeter, based on roof-area definitions in FMG Loss Prevention Data Sheet 1-28.

B. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of 1/2 of the span or 18 inches, and as follows:

1. Mechanically fasten with self-drilling, No. 10 diameter or larger, carbon-steel screws.
2. Fasten with a minimum of 1-1/2-inch-long welds.

C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches, with end joints as follows:

1. End Joints: Lapped 2 inches minimum or butted at Contractor's option.

D. Miscellaneous Roof-Deck Accessories: Install ridge and valley plates, finish strips, end closures, and reinforcing channels according to deck manufacturer's written instructions. Weld or mechanically fasten to substrate to provide a complete deck installation.

1. Weld cover plates at changes in direction of roof-deck panels unless otherwise indicated.

E. Flexible Closure Strips: Install flexible closure strips over partitions, walls, and where indicated. Install with adhesive according to manufacturer's written instructions to ensure complete closure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Field welds will be subject to inspection. Testing agency will report inspection results promptly and in writing to Contractor and Engineer.

C. Remove and replace work that does not comply with specified requirements.

D. Additional inspecting, at Contractor's expense, will be performed to determine compliance of corrected work with specified requirements.

3.5 PROTECTION

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

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 - GENERAL

1.1 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. Preformed channel pipe supports.
8. Stairs.
9. Miscellaneous metals.
10. Associated accessories to the above items.

1.2 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.

1.3 REFERENCES

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.

A. Aluminum Association (AA):

1. Specification M12-C22-A41 - Aluminum Finishes.

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

1. Standard Specifications for Highway Bridges.

C. 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.

D. American Welding Society (AWS):

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

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

1. Metal Finishes Manual.

F. Occupational Safety and Health Administration (OSHA).

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

1.4 - 1.5 (NOT USED)

1.6 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, “Submittals”:

B. Product Data:

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

C. Shop Drawings:

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

D. 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.

1.7 - 1.11 (NOT USED)

PART 2 - PRODUCTS

2.1 MANUFACTURERS (NOT USED)

2.2 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 B 308	Alloy 6061-T6
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.

2.3 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 2.03.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) McNichols Company.
        2) IKG Borden Industries.
        3) 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. Preformed Channel Pipe Supports:

1. Preformed channel pipe supports for pipe supports and other applications are specified in Section 15066.

H. 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 2.03.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.

I. 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

3.1 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.

3.2 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.

3.3 - 3.10 (NOT USED)

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 05520

ALUMINUM HANDRAILS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 RELATED REQUIREMENTS (NOT USED)

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.

ALUMINUM ASSOCIATION (AA)

ASD-1	Aluminum Standards and Data
DAF-45	Designation System for Aluminum Finishes
SAA-46	Standards for Anodized Architectural Aluminum

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A193/A193M	Standard Specification for Ally-Steel and Stainless Steel Bolting Materials for High Temperature Service
ASTM B429	Standard Specification for Aluminum All Extruded Structural Pipe and Tube
ASTM F593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

AMERICAN WELDING SOCIETY (AWS)

AWS D1.2	Structural Welding Code Aluminum

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

29 CFR 1910	OSHA Regulation Safety and Health Standards for General Industry

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

IBC	International Building Code

1.04 DEFINITIONS

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

1.05 SYSTEM DESCRIPTION (NOT USED)

1.06 SUBMITTALS

Submit the following in accordance with Specification Section 01300, “Submittals”.

A. Product data for materials used.

B. 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.

C. 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.

D. Field layout of fabricated sections to ensure proper fit during erection, after fabrication and finishing, and prior to shipment.

E. Certificate of Conformance as required in Paragraph 1.07 – Quality Assurance.

1.07 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.

1.08 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.

1.09 – 1.11 (NOT USED)

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

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 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 to 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 to 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. Nonwelded 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 M43C22A4l.
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 to be set flush or recessed. All fasteners to be Type 316 stainless steel.
4. Unless otherwise noted on PLANS, all handrails to be nonwelded 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 to 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

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

2.04 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 - 3.02 (NOT USED)

3.03 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 to 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.

3.04 - 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 08100

FIBERGLASS DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY

Furnish and install fiberglass reinforced plastic doors, frames and related accessories.

1.02 RELATED REQUIREMENTS

A. PLANS define locations, sizes, and special features or accessories.

B. Related work as called for on PLANS or specified 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.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials

1.04 - 1.05 (NOT USED)

1.06 SUBMITTALS

A. Furnish in accordance with Specifications Section 01300, “Submittals”.
   1. Shop Drawings. In addition to the items specified in Section 01300, “Submittals”, furnish the following:
      a. Product Data. Manufacturer’s specifications describing features, colors, options, and accessories.
      b. Drawings with pertinent dimensions, hardware locations, transom and lite sizes, door elevations.
      c. Location and details of anchorage devices to be embedded in or fastened to other construction. Furnish templates if required for accurate placement.
      d. Schedule of openings coordinated with numbering system used in Contract Documents.
      e. Samples for Color Selection: Submit custom color charts showing full range of colors and finishes available.

1.07 QUALITY ASSURANCE

Guarantee doors and frames for 5 years against delamination, discoloration, and warping.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver products in crates or cartons suitable for storage at the site.

B. Store in original cartons on end in a manner to prevent falling and protect to prevent damage until erected and accepted.

C. Store products under cover and raised above ground level.

1.09 - 1.11 (NOT USED)

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the requirements of this Section, the following manufacturers have the capability of performing the work in this Section:
   1. CHEM-PRUF Door Company.
   2. No “or Equal”

2.02 MATERIALS AND/OR EQUIPMENT

A. Doors:
   1. Fiberglass reinforced plastic (FRP) using polymers selected for specific corrosive environment and containing a glass content of 25% by weight.
   2. Construction to be flush panel with no seams or cracks and all mortises molded in by manufacturer. Mortises are not to be routed or cut out of the stile structure or the jambs.
   3. Thickness: 1¾”.
   4. Color gel coat 12 to 18 mil thick.
   5. Insulating R-factor: R12 minimum.
   6. Stiles, and rails to have color gel coat followed by 3 layers of 1.5 ounce per square foot random mat. Mold style and rail structure in a continuous piece to a "U" configuration to exact door dimensions. Compression member inside the "U" to fit tightly with no voids. Pultrusions are not acceptable for stiles and rails.
   7. Mold plates in one continuous piece with two layers of 1.5-ounce glass mat and with 16 ounces unidirectional roving.
   8. Fill area between door plates completely with 4 to 6-pound density polyurethane foam, flame spread of 25 or less per ASTM E84.
   9. Reinforcing resins to be of fire retardant formulation with antimony tri-oxide and have a flame spread of 25 or less per ASTM E84 and be self-extinguishing per ASTM D635.
   10. Provide reinforcement and compression members to receive half-surface hinges, closers, locks, latchsets, kick plates, pull handles, or panic devices as scheduled.

11. Ledge for window openings to be one-piece structure molded integrally with both door plates to prohibit penetration of moisture into door cavity. Window lights to be structurally retained by 4 fiberglass glazing pins and positively sealed.
12. Windows: ¼" polished safety glass.

B. Door Frames**:**
1. Door frames to be similar to the doors in construction and materials except the frames to be solid fiberglass, ¾″ × 5¾″, unless noted otherwise on the PLANS. Mold stop and frame in one piece. Frame to be integrally gelcoated to the color specified or selected. Mortises to be molded in. It is not permitted to rout in mortises or remove any material from the head or jambs, to provide mortises.
2. Reinforcement for mounting hinges, closers, etc., to be mild steel plates strategically located and buried in the resin-glass matrix so they are not exposed to the elements.
3. The jamb to be flat on the backside (against the opening) and uniform in thickness so as to provide a solid, uniform surface against the wall opening. No wood blocks or spacers are permitted.

C. Transoms: Transoms to be identical to the doors in construction, materials, thickness and reinforcement.

D. Louvers: All parts, jambs, header, sill, slats, or vanes to be made of gelcoated fiberglass reinforced plastic (FRP) using resins tailored to a specific corrosive environment, flush construction. Ratio of glass to resin to be at least 25:75. The color of the louver to match door and to be integrally molded as the part is made. Provide each louver with a bug screen and FRP rain drip.

E. Hardware:
1. Finish hardware for fiberglass doors to be furnished by door manufacturer who will also machine doors and frames to receive hardware at job site.
2. Furnish door hardware per applicable specification section.
3. Doors supplied with closers, to have a 4”x 8” stainless steel Type 316 anchor plate attached to each side of the door at the closer thru-bolt locations. Plate to be same thickness as manufacturer’s standard kickplate.

PART 3 - EXECUTION

3.01 GENERAL

Inspect substrates and conditions under which the work of this Section will be performed, and verify that installation properly may commence. Do not proceed with the work until unsatisfactory conditions have been resolved fully.

3.02 PREPARATION (NOT USED)

3.03 ERECTION, INSTALLATION, AND APPLICATION INSTRUCTIONS

A. Frames: Erect plumb and square in the opening. Bond frame to wall per installation kit and instructions supplied with frames. Secondary attachment to be accomplished with anchors and stainless steel bolts to suit concrete wall panels or masonry as required and furnished with installation kit.

B. Doors:
   1. Doors to be hung and all scheduled hardware applied in strict accordance with manufacturer's instructions. Job site installation to be accomplished using manufacturer's plant preparation with no cutting or drilling at job site except for weatherstripping.
   2. Space between door and frame to be uniform. Hardware to operate smoothly and hold door snugly in closed and hold open position.

3.04 – 3.05 (NOT USED)

3.06 ADJUSTING

Final Adjustments: Upon achieving substantial completion of the work, adjust all operable components to ensure that they are properly installed and functioning smoothly. Replace any component which cannot be adjusted for proper operation.

3.07 CLEANING

A. Upon completion, clean all surfaces which have become soiled or coated as a result of work of this Section, using proper methods which will not scratch or otherwise damage finished surfaces.
   1. For cleaning, use only products and techniques acceptable to manufacturer of products being cleaned.

3.08 - 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 09902

PAINTING AND PROTECTIVE COATINGS

PART 1 GENERAL

1.01 SUMMARY

A. Furnish and apply, as specified herein, paint and protective coatings to all surfaces, except steel water storage tanks, unless specifically excluded by this Section.

1.02 RELATED REQUIREMENTS

A. PLANS define special coating requirements.

B. Related work as called for on PLANS, or 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.

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC SP-1	Surface Preparation Specification No. 1 - Solvent Cleaning
SSPC SP-2	Surface Preparation Specification No. 2 - Hand Tool Cleaning
SSPC SP-3	Surface Preparation Specification No. 3 - Power Tool Cleaning
SSPC SP-5	Surface Preparation Specification No. 5 - White Metal Blast Cleaning
SSPC SP-6	Surface Preparation Specification No. 6 - Commercial Blast Cleaning
SSPC SP-7	Surface Preparation Specification No. 7 - Brush-Off Blast Cleaning
SSPC SP-8	Surface Preparation Specification No. 8 - Pickling
SSPC SP-10	Surface Preparation Specification No. 10 - Near-White Blast Cleaning

NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)

NACE No. 1	White Metal Blast Cleaning
NACE No. 2	Near-White Blast Cleaning
NACE No. 3	Commercial Blast Cleaning
NACE No. 4	Brush-Off Blast Cleaning

1.04 DEFINITIONS (NOT USED)

1.05 SYSTEM DESCRIPTION

A. Surfaces receiving coatings include:
1. Equipment, machinery, and metal surfaces.
2. Interior surfaces, as noted in room finish schedule.
3. Concrete surfaces, including concrete blocks (when noted on PLANS).
4. Threads on field-threaded galvanized pipe and conduit.
5. All cabinet and woodwork. (Stain finish unless otherwise noted.)
6. Interior concrete surfaces of new lift station wet wells.

7. Paint concealed structural steel and steel joists, after erection of deck and before steel is enclosed.
8. Procedures and coating systems specified herein are in addition to shop priming and surface treatment specified in other TECHNICAL SPECIFICATION Sections.

B. Unless otherwise noted or shown, the following areas or items do not require coating:
1. Non-ferrous and corrosion-resistant ferrous alloys such as copper, bronze, monel, aluminum, stainless steel, chromium plate, and atmospherically exposed weathering steel, except where:
   a. Required for electrical insulation between dissimilar metals;
   b. Aluminum and stainless steel are embedded in concrete or masonry, or aluminum is in contact with concrete or masonry;
   c. Color coding of equipment and piping is required.
2. Non-metallic materials such as glass, PVC, porcelain, and fiberglass, except as required for architectural painting or color coding.
3. Pre-finished electrical and architectural items such as motor control centers, switchboards, switchgear, panelboards, transformers, disconnect switches, panelboards, acoustical tile, cabinets, elevators, building louvers, etc., except when color coding of equipment is required.
4. Non-submerged electrical conduits attached to unpainted concrete surfaces.
5. Items specified to be galvanized after fabrication unless specified elsewhere or subject to immersion.
6. Insulated piping except as required for architectural painting or color coding.

1.06 SUBMITTALS

Submit the following in accordance with Specification Section 01300, “Submittals”.

A. Painting Schedule: Submit list indicating major items to be painted, preparation, paint manufacturer, product designation, and dry mil thickness.

B. Panels
1. Submit panels containing samples of proposed paints and coatings. Include three displays of each kind and color of paint used. Panel to be representative of material to be coated.
2. Mark panels to indicate respective types of surfaces to which several kinds and colors of paint, stain, and coating are applied.

C. Samples: If requested by OWNER, submit 1/4 pint of each kind of paint or stain proposed for use. Do not deliver materials to site until representative samples (if requested) have been approved.

D. For all materials, furnish ENGINEER with two sets of manufacturer’s printed instructions describing surface preparation procedures and application procedures including environmental limits (temperature and humidity).

E. List of five similar projects in accordance with Paragraph 1.07 B.1.

F. Material Safety Data Sheets (MSDS) for all coatings, solvents, sealers, and paints to be utilized.

1.07 QUALITY ASSURANCE

A. Manufacturer: All paints, sealers, and coatings to be manufactured by those firms listed in Table 2. Products of equal quality by other manufacturers will be considered, subject to review of written submittal that includes product data and a detailed paint and coating schedule.

B. Workmanship

1. Furnish workers who perform quality work and who are experienced and knowledgeable in the surface preparation and application of high-performance industrial coatings. Submit list of five similar projects which have been prepared and coated by the personnel which the CONTRACTOR proposes to employ for this project.
2. Submit manufacturer's written instructions on cleaning and coating prior to any surface preparation or coating.

C. Whenever possible, all coatings should be from single manufacturer. Unless otherwise specified, coating materials for a specific surface or piece of equipment are to be from a single manufacturer.

D. All coatings provided for use on this project in the field or from equipment suppliers will be in compliance with Federal, State, and local laws, regulations and ordinances related to items such as lead, chromate, carcinogens and volatile organic compounds. For potable water systems, all coatings and products used on surfaces 1) in contact with the water, 2) within 1 foot above the high water level and below the high water level, or 3) in contact with materials to be introduced into the water, to be National Sanitation Foundation (NSF) approved for potable water service.

1.08 DELIVERY, STORAGE AND HANDLING

A. Deliver to site in original, sealed containers with manufacturer's label attached.

B. Store in a protected area that is heated or cooled to maintain temperature range recommended by manufacturer. Protect all materials from weathering and extreme temperatures.

C. Waste and any hazardous material remaining at the end of the day to be discarded in accordance with national, state, and local regulations.

1.09 - 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Coating manufacturers are listed by generic type and service in Table 2 attached to this Section.

2.02 MATERIALS

A. Tables 1 and 2 in this Section include the paint, protective coatings, and sealers for this project. Furnish all such special materials required for the manufacturer's coating systems whether or not included in the Tables.

B. Products to comply with Federal, State, and local requirements limiting the emission of volatile organic compounds. The maximum volatile organic content of the combination of coating and thinner is not to exceed the following limits (whichever is less):
1. 3.5 pounds per gallon; or
2. The Federal, State or local limit.

C. Colors
1. OWNER reserves the right to select colors.
2. Submit list of items to be painted and color charts for each type of surface.
3. Formulate with colorants free of lead or lead compounds.
4. Proprietary color identification is for selection purposes only. Any authorized manufacturer may supply matches.

D. Safety Color Codes: Follow OSHA requirements of 29 CFR, Part 1910.144 for "Safety Color Codes for Marking Physical Hazards". The following general requirements are set forth as a guide.

1. Red: Fire protection equipment, danger signs, and fire exit signs. Portable containers of flammable material to be red with yellow band or name of contents stenciled in yellow.
2. Orange: Moving or rotating parts of equipment protected by guards, including shafts and couplings, pulleys, and sprockets. (Do not paint wearing surfaces.)
3. Yellow: Caution signs and all physical hazards, including outside levers and weights on check valves, lower pulley blocks and hooks, sprockets and chains on valve operators, inside of openings adjacent to step or ladders, platforms provided for vertical ladders at transition levels, exposed unguarded edges of pits, platforms and walls subject to being struck, and any piping or equipment extending into normal operating areas.
4. Green: To designate "Safety" and location of first-aid equipment such as gas masks, first-aid kits, and safety deluge showers.
5. Black and White: To indicate areas that must remain clear, such as areas around first-aid, fire-fighting, and other emergency equipment.

E. Piping Color Coding: The identification of process piping and chemical feed lines is to be accomplished by various colors of paint. Color coding to be by solid color and labels. Provide pipe color coding in accordance with applicable Specification Section.

1. Wastewater Plant Color Codes:

LETTERING	COLOR OF PIPE
Sludge	Brown
Natural gas	Red
Potable water	Light Blue
Chlorine	Yellow
Sulfur dioxide	Lime green with yellow bands
Sewage	Grey
Compressed air	Light Green
Heated water	Blue with 6 inch red bands spaced 30 inches apart
Power conduit	In compliance with the National Fire Protection Association 70 National Electrical Code®
Reclaimed water	Purple with black lettering
Gray water	Purple with yellow writing
Instrument air	Light green with dark green bands;
Liquid alum	Yellow with orange bands
Alum (solution)	Yellow with green bands
Ferric chloride	Brown with red bands
Ferric sulfate	Brown with yellow bands
Polymers	White with green bands
Ozone	Stainless steel with white bands
Raw water	Tan
Effluent after clarification	Dark green

2. Piping containing gas, chlorine or other hazardous materials are to be color coded when exposed, located out of view, or buried.
3. Non-potable water lines are to be painted white and marked with black lettering at maximum 5-foot intervals.

2.03 - 2.04 (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Use one convenient location for storing and mixing of materials and keep fire extinguisher available in this area as long as location is used for such purpose.

B. Thinners and Solvents: Use only those thinners and solvents specified in paint formulas of paint being used and mix in proportions recommended by paint manufacturer.

C. Coverage: As recommended by paint manufacturer and sufficient to obtain minimum mil thickness specified. Do not exceed maximum thickness specified by manufacturer, if applicable. After final coat is applied, check with elecometer or Mikrotest dry film thickness gauge.

D. Drying Time: Between successive coats, allow drying time as specified by paint manufacturer. Do not apply additional coats until previous coat is completed.

E. Provide adequate ventilation for proper curing. Keep materials sealed when not in use.

F. Environmental conditions such as temperature and humidity to be within the ranges recommended by the coating manufacturer.

G. Finish coats to be smooth, free of brush marks, streaks, laps or pile up of paints, and skipped or missed areas. Finished metal surfaces to be free of voids or pinholes in any coat when tested with a low voltage detector.

3.02 PREPARATION

A. General
   1. Perform all preparation and cleaning procedures in strict accordance with paint manufacturer's instructions and as specified for each substrate.

B. Concrete Surfaces
   1. Prior to painting, surfaces to be free of all latent matter, burrs, and fins, using one or more of the following methods.
      a. Remove oil and grease with detergent and thoroughly rinse with fresh water.
      b. Abrasive blasting may be used only if machinery or other equipment in vicinity of work is adequately protected. Also, avoid settling of dust or grit on freshly painted surfaces.
      c. Wash concrete surfaces with 10 percent solution of muriatic acid, then wash clean and free of scale, mortar, dust, moisture, and other foreign matter.
      d. Repair all honeycomb surface defects by coating cleaned honeycombed area with epoxy bonding agent and filling voids with non-shrink grout leaving a smooth uniform concrete surface.
   2. If curing compound is used, it must be removed prior to coating.

C. Metal Surfaces
   1. Clean metal surfaces by abrasive blasting in shop as required by Table l and leave clean, dry, and ready to receive prime coat. Provide moisture separators to effectively remove all oil and free moisture from air supply. Cleanliness of air to be tested by impinging an abrasive-free air stream onto a white cloth for one minute. If oil or moisture is detected, air source to be shut down and corrected.
   2. Remove all dust and abrasives from surfaces by brushing or blowing with clean, dry air. Remove abrasive grit around and between joints of connecting members.

3. Perform field abrasive blasting only if required to correct unsatisfactorily cleaned and shop-primed metal and when approved by ENGINEER.
4. Removal of Oil and Grease: Remove oil and grease with a solvent approved by coating manufacturer, or by steam combined with detergent (in accordance with SSPC SP-1). Use of gasoline, kerosene, naphtha, or carbon tetrachloride not permitted.
5. Brushing, Scraping, Grinding, and Chipping: In field work, if abrasive blasting is not possible, scrapers, wire brushes, and other suitable grinding or chipping tools may be used (in accordance with SSPC SP-2 or SP-3) for removal of existing paint coatings prior to repainting, or for cleaning, before applying second coats.
6. Surface to be coated on same day as cleaned and before rust bloom occurs. Surfaces which have been cleaned but which have started to show signs of rust or dirt are to be cleaned again prior to coating at no additional expense to OWNER.
7. All surfaces to be at least 5°F or higher above the dew point and remain this way when blasting, priming, or coating.

D. Galvanized Surfaces
1. Clean surface with mineral spirits to remove oil residue.
2. Dry with a clean cloth.

E. Wood Surfaces
1. Clean soiled surfaces in accordance with coating manufacturer's instructions.
2. Sand to a smooth even surface and then dust off.
3. Apply shellac to all knots, pitch and resinous sapwood before priming coat is applied.
4. Fill nail holes, cracks, open joints and other defects with putty after priming coat has dried. Tint putty to match finish color. Sand smooth after putty dries.
5. Apply priming coats to woodwork as soon as practical after woodwork is delivered.
6. Top and bottom edges of all wood doors to be primed and sealed after fitting and before final hanging.

F. Gypsum Wallboard
1. Fill narrow, shallow cracks and small holes with spackling compound.
2. Rake deep, wide cracks and deep holes.
   a. Dampen with clean water.
   b. Fill with thin layers of drywall joint compound
3. Allow repairs to dry.
4. Sand smooth. Do not raise nap of paper on wallboard.

G. Plastic Surfaces:
1. Hand sand plastic surfaces to be coated with a medium grit sandpaper to provide tooth for coating system.
2. For surfaces with existing coatings, completely remove any existing coating and prepare surface as mentioned above.

3.03 ERECTION, INSTALLATION AND APPLICATION INSTRUCTIONS

A. General
1. Do not apply initial coating until moisture content of surface is within limitations recommended by paint manufacturer. Test with moisture meter.
2. Slightly vary the color of successive coats.
3. Sand and dust between each coat to remove defects visible from a distance of 5 feet.

4. Make edges of paint adjoining other materials or colors clean and sharp with no overlapping.
5. Change colors at corner of stop where colors differ between adjoining spaces or rooms and where door frames match wall colors.
6. Do not proceed with field applied painting of shop-coated items until any defective work has been cleaned by sandblasting.

B. Brush Application
1. Brushes: Use first-quality hog hair or suitable synthetic bristle brushes. Use of horsehair bristle brushes not permitted. Keep brushes clean and free from accumulation of dried paint or dirt, and when brushes for oil or varnish base paints are not in use, keep them suspended in raw linseed oil bath. Clean brushes with proper solvent before reuse.
2. Application: Apply in uniform thickness consistent with specified coverage and with sufficient cross-brushing to ensure filling of surface irregularities. Exercise particular care in painting around bolt heads and nuts and in corners and other restricted spaces.

C. Conventional Spray Application: Apply with adjustable air gun equipped with suitable water trap to remove moisture from compressed air, and with paint pot having air driven or mechanical agitator. Adjust width of spray to meet the requirements of the surface being coated with suitable air pressure for the particular type of paint being used. Make frequent checks to ensure correct spreading rate and coating and apply without sags, runs, or “orange peel” effect. Correct all such imperfections. Take special care to cover edges, corners, and bolt heads, without bridging over of paint film.

D. Airless Spray Application: Equipment used for airless spray to be designed for, and capable of handling, the volume and pressures necessary to ensure smooth and proper application. Hoses to be specifically designed for the viscosity of the material being sprayed and be of the non-static, self-grounding type. Tips to be properly sized to ensure complete atomization and the spray pattern is to be continuous and free of all fingering effects.

E. Roller Application: Proper length nap rollers to be used to ensure a smooth application free of runs, sags, roller marks, or air bubbles. Use longer nap for rougher surfaces when specified on PLANS. Phenolic core lambs wool type rollers to be used when polyurethanes, epoxies, or other types activated coatings are applied by roller. Standard type rollers to be used on water based and enamel coatings. Rollers to be of sufficient quality to leave finished surfaces free of lint, roller nap, runs, sags, and other imperfections. Roller is not to exceed 24 inches in length.

F. Metal Surfaces
1. Shop-prime metal surfaces, if required, prior to delivery to job site.
2. After delivery and prior to installation, keep all coated metal surfaces clean and free from corrosion. Clean and touch up or repaint damaged areas with additional primer.
3. After erection or installation of metal work, clean and touch up all rust spots, all places where primer has been rubbed or scraped off, and all bolts and nuts. After previously applied paint has hardened, and when surfaces to receive succeeding coats of paint have been cleaned and dried, apply finish paint in accordance with Tables 1 and 2. Allow 7 days or more, as recommended by coating manufacturer, for curing of final coat for submerged surfaces.
4. Factory-Finished Equipment: After installation of factory-finished machinery and electrical equipment, check base coats carefully and touch up all damaged surface areas. Do not paint nameplates, serial number bases, chrome, or bronze trim. Clean off any excess paint that impairs convenient removal of covers on gauges, instrumentation, or other equipment fitted with doors or covers.

5. Factory-Primed Equipment: Delay final field coating to manufacturer's primed equipment until equipment has been installed and is in proper working order in accordance with the applicable Section.

G. Mixing and Tinting
1. Deliver paints and enamels ready mixed to job site.
2. Accomplish job mixing and job tinting only when acceptable to the ENGINEER.
3. Mix only in mixing pails placed in suitably sized non-ferrous or oxide resistant metal pails.
4. Use tinting colors recommended by manufacturer for the specific type of finish.
5. Multiple-Component Coatings:
   a. Prepare using all the contents of the container for each component as packaged by the manufacturer.
   b. No partial batches permitted.
   c. Do not use multiple component coatings that have been mixed beyond their pot life.
   d. Provide small quantity kits for touch up painting and for painting small areas.
   e. Mix only components specified and furnished by coating manufacturer.
   f. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

H. Special Requirements: Cast iron or ductile iron piping and valves for interior and exterior aboveground installation with a factory-applied bitumastic or asphaltum varnish coating to be cleaned by abrasive blasting to a NACE No. 3 finish for interior installations and a NACE No. 2 finish for exterior surfaces. Primer and finish coat to be applied in accordance with Table 1. If primer is not applied within 24 hours, surfaces to be retreated.

3.04 REPAIR/RESTORATION

A. Leave all parts of moldings and ornaments clean and true to details with no undue amount of paint in corners and depressions.

B. Remove all masking products used to protect hardware or built-in work.

C. Final Cleaning and Touch Up
1. Touch up and restore finish where damaged.
2. Do not mar surface finish of item being cleaned.

D. Refinish whole wall where portion of finish has been damaged or is not acceptable.

E. Damaged Coatings, Pinholes and Holidays
1. Feather edges and repair in accordance with recommendations of coating manufacturer.
2. Repair fusion bonded coatings as recommended by original applicator. Applicator to furnish liquid repair kits for this purpose as recommended by the coating manufacturer.
3. Apply finish coats, including touch up and damage-repair coats, in a manner which presents a uniform texture and color-matched appearance.

F. Unsatisfactory Application
1. If coating has improper finish color or insufficient film thickness: Clean and top coat surface with specified material to obtain specified color and coverage. Obtain and follow specific surface preparation information for top coating from coating manufacturer.

2. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat in accordance with this Section. Depending on extent of repair and appearance, a finish sanding and top coat may be required.
3. Evidence of runs, sags, bridges, shiners, laps, or other imperfections to be cause for rejection.
4. Repair defects in coating system per written recommendations of coating manufacturer.
5. Leave all staging in place until ENGINEER has inspected surface or coating. Replace staging removed prior to inspection and approval by ENGINEER.

3.05 FIELD QUALITY CONTROL

A. Schedule field operations to avoid settling of dust or grit on freshly painted surfaces, and adequately protect machinery or other equipment in vicinity of abrasive blasting work.

B. Request review by OWNER of first finished room, space, or item, of each color scheme for color, texture, and workmanship.

C. Use first acceptable room, space or item (as determined by OWNER), as project standard for each color scheme.

D. For spray application, paint an area no smaller than 100 square feet as the project standard.

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. During the progress of the work, remove from the project site at the close of each day's work, all oily rags, discarded materials, rubbish, cans, and dispose of in accordance with national, state, and local regulations.

B. On completion of operations, remove all spots, oil, and stain from all surfaces and leave entire project in clean condition as far as this work is concerned.

C. Remove from premises all containers and debris resulting from this work and dispose of in accordance with Federal, State and local regulations.

D. Upon completion of the work remove staging and scaffolding from the site.

3.08 TESTING AND INSPECTION

A. CONTRACTOR is to perform routine quality control testing on each coat to ensure the integrity of the protective coating. At a minimum, the following tests are to be performed.
1. Dry film thickness.
2. Holiday testing.
3. Any additional tests as recommended by coating manufacturer.

B. Any and all testing performed by the ENGINEER is for the sole purpose of verifying compliance with this specification. CONTRACTOR is not to rely upon testing performed by the ENGINEER as a means of quality control.

C. CONTRACTOR to provide the following equipment for use by the ENGINEER.
1. One magnetic pull-off type, non-destructive paint film thickness gauge, such as a Mikrotest thickness gauge. Thickness gauge to become OWNER's.

2. One set of certified coating thickness calibration standards produced by the U.S. Department of Commerce. Calibration standards to become OWNER's.
3. One "wet sponge", low voltage, D.C. type holiday detector, such as the Tinker-Rasor Electrical Holiday Detector.

D. Provide the ENGINEER with the proper safety equipment for observation and testing of the applied coating.

E. To facilitate ENGINEER's inspection of coated surfaces, CONTRACTOR to provide scaffolding/rigging and adequate illumination as required to perform the dry film thickness reading and holiday test inspections as required by this specification and the referenced standards. Provide personnel to move the scaffolding, lighting, or rigging at the request of the ENGINEER.

F. No equipment is to be placed in service until the protective coating has been tested and approved by the ENGINEER.

3.09 PROTECTION

A. CONTRACTOR is solely and completely responsible for conditions of the job site including safety of all persons (including employees) and property during performance of the work. This requirement applies continuously and is not limited to normal working hours. Conform with safety provisions of the U.S. Department of Labor, Occupational Safety and Health Act, any equivalent State law, and all other applicable Federal, State, and local laws, ordinances, and codes.

B. Protect floors and all other areas where work is done, with suitable drop cloths.

C. Remove, mask, or otherwise protect all hardware, hardware accessories, lighting fixtures, switchplates, machined surfaces, couplings, shafts, bearings, labels, nameplates, etc. and other surfaces not intended to be painted prior to surface preparation and painting. Reinstall the removed items by workmen skilled in the trades involved.

D. CONTRACTOR is cautioned of the potential risk of damage and/or nuisance to the adjoining property and/or structures. CONTRACTOR is responsible for providing necessary equipment and/or controls to minimize the carryover of dust, paint, and abrasives. If excessive dust, paint, or abrasives are determined by the OWNER, or their representative, to be affecting adjoining property and/or structures, CONTRACTOR to utilize shrouds, drop tubes, or other means to confine a minimum of 95 percent of the abrasive, paint, and other material to the associated work area.

E. Protect working parts of mechanical and electrical equipment from damage. Mask openings in motors to prevent paint and other materials from entering motor.

3.10 SCHEDULES

A. Attachments to this Section define System Schedule (Table 1) and Coating Schedule (Table 2).

3.11 MEASUREMENT AND PAYMENT

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.

TABLE 1 – SYSTEM SCHEDULE

Type of Surface	Exposure	Surface Preparation/ Cleaning	Table 2 – Material Reference				Minimum Total Mils Thickness
			Primer	1st Coat	2nd Coat	3rd Coat	
Clay or Brick Masonry	Exterior(1)	Manufacturer's Specification	—	1	—	—	NA
Concrete Block Buildings	Exterior	Manufacturer's Specification	—	2	4	4	3.0 (Finish Coat)
Concrete Block Walls	Interior(2) - Painted	Paragraph 3.02 B	—	3	4	4	3.0 (Finish Coat)
	Interior(2) - Sealed	Paragraph 3.02 B	—	3A	—	—	NA
Concrete Walls and Ceilings	Interior	Paragraph 3.02 B	—	3	4	4	3.0 (Finish Coat)
Wood	Exterior and Interior	Manufacturer's Specification	10	11	11	—	4.5
Wood, Clear Finish, Satin	Interior	Manufacturer's Specification	23, 24	25	26	26	4.0
Wood, Clear Finish, Gloss	Interior	Manufacturer's Specification	23, 24	25	27	27	4.0
Wallboard (Semi-Gloss)	Interior	Manufacturer's Specification	19	20	22	22	4.0 + texture
Wallboard (Flat)	Interior	Manufacturer's Specification	19	20	21	21	4.0 + texture
Metal Doors, Frames and Windows	Exterior and Interior	NACE-#4 1.0 Mils Surface Profile	18	9	—	—	4.0
Structural and Misc. Steel	Exterior	NACE-#2 1.0-2.0 Mils Surface Profile	16	18	9	—	7.0
Structural and Misc. Steel	Interior	NACE-#3 1.0-2.0 Mils Surface Profile	16	17	—	—	5.5
Piping and Valves	Interior(2)	NACE-#3	6	17	—	—	4.5
	Exterior(1)	NACE-#2 1.0-2.0 Mils Surface Profile	6	18	9	—	6.0
Valves and Bolting on C.I. Pipe	Buried	—	—	14	14	—	32.0

TABLE 1 – SYSTEM SCHEDULE

Type of Surface	Exposure	Surface Preparation/ Cleaning	Table 2 – Material Reference				Minimum Total Mils Thickness
			Primer	1st Coat	2nd Coat	3rd Coat	
Factory Finished Machinery, Electrical, and Motors(3)	Interior and Exterior	Hand Clean	5(4)	8(5)	8(5)	—	4.5
Galvanized Steel	Interior	Solvent Cleaning	15	17	—	—	2.9
Galvanized Steel and Galvanized Pipe Conduit Threads	Exterior	Solvent Cleaning	15	18	9	—	4.4
Wastewater Treatment Plant Equipment, Piping	Submerged(6)	NACE-#2 2.0-3.0 Mils Surface Profile	28	29	—	—	45.0
Wastewater Wet-Well	Interior Surfaces	Paragraph 3.02 B	6	13	13	—	22.0
Special Surfaces Noted on PLANS	Surfaces as Shown on PLANS	Hydroblast and SSPC SP-7(8)	28	29	—	—	125.0

NOTES:
(1) Surface or piping above ground exposed to weathering.
(2) Surface or piping above ground sheltered from weathering.
(3) Use coating system per equipment Section when specified.
(4) Optional: Use manufacturer's standard primer if compatible with specified finish coats.
(5) Optional: Use manufacturer's standard finish coat.
(6) Piping or equipment that is submerged or partially submerged in a fluid.
(7) Coatings used must be in the latest publication of National Sanitation Foundation (NSF) ANSI/NSF Standard 61.
(8) Shop priming on iron/steel materials is not required. Surface preparation and primer are done in field. Concrete surface preparation involves ¼″ wide × ¼″ deep saw cut to anchor coating to surface.

TABLE 2 – COATING SCHEDULE

Symbol	Min. Dry Mils Per Coat*	Service	Generic Type	Brand and Manufacturer
1.	NA	Primary Sealer	Chemical Penetrant	Aqua-Gard - CreteGard Corp. Seal Krete - ICI Devoe #89424
2.	NA	Weather-proof Primary Sealer	Acrylic Emulsion	ACRO 2290 DTM Acrylic Latex - ACRO Amercoat 148 - Ameron Tru-Glaze 4010 - ICI Devoe
3.	NA	Primary Sealer	Vinyl-Acrylic Emulsion with Epoxy Esters	ACRO 1153 Latex Block Filler - ACRO Amercoat 148 - Ameron

TABLE 2 – COATING SCHEDULE

Symbol	Min. Dry Mils Per Coat*	Service	Generic Type	Brand and Manufacturer
				Blaxfil 4000 - ICI Devoe
3A.	NA	CMU, Clear Block Sealer	Siloxane Sealer, 10% Siloxane-Acrylic Emulsion	OKON W-2 Saver Systems WB Aqua-Trete EM - Sivento
4.	1.5	Finish Coat	Acrylic Emulsion	ACRO 2288 Exterior Latex - ACRO Amercoat 220 - Ameron LifeMaster-Pro 4226 - ICI Devoe
5.	1.5	Metal Primer	Alkyd	ACRO 1104 Heavy Duty Primer - ACRO Amercoat 5105 - Ameron Carbocoat 150 - Carboline Devguard 4160 - ICI Devoe
6.	2.0	Metal Primer or Concrete Surfaces	Polyamide Cured Epoxy Resin	ACRO 4422 Epoxy Primer - ACRO Amercoat 385PA - Ameron Carboguard 888 - Carboline 13-R-62-Epoxy Primer - Valspar BarRust 231 - ICI Devoe
7.**	2.0-4.0 (as recommended)	Metal Primer	Polyamide Cured Epoxy Resin	ACRO 4460 Chemical Resistant Epoxy - ACRO Amercoat 385PA - Ameron Carboguard 561 - Carboline Valspar 90HS - Valspar BarRust 233H - ICI Devoe
8.	1.5	Finish Coats	Alkyd, Straight Long-Oil	ACRO 2214 Heavy Duty Enamel - ACRO Amercoat 5450 - Ameron Carbocoat 139 - Carboline Devguard 4308 - ICI Devoe
9.	2.0	Finish Coat	Aliphatic Urethane	ACRO 4429 Polyurethane - ACRO Amercoat 450HS - Ameron Carbothane 134HG - Carboline V40 Polyurethane Enamel - Valspar Devthane 389 - ICI Devoe
10.	1.5	Wood Primer	Oil Base	ACRO 2214 Enamel (Thinned 10%) - ACRO Amercoat 5105 - Ameron Carbocoat 139 - Carboline Ultrahide 2110 - ICI Devoe
11.	1.5	Finish Coat	Alkyd, Straight Long-Oil	ACRO 2214 Heavy Duty Enamel - ACRO Amercoat 5405 - Ameron Carbocoat 139 - Carboline Devguard 4308 - ICI Devoe
12.**	4.0-6.0 (as recommended)	Submerged Steel, Iron, or Concrete Surface	Polyamide-Cured Epoxy Resin	ACRO 4460 Chemical Resistant Epoxy - ACRO Amercoat 370 - Ameron Carboguard 561 - Carboline

TABLE 2 – COATING SCHEDULE

Symbol	Min. Dry Mils Per Coat*	Service	Generic Type	Brand and Manufacturer
				BarRust 231 - ICI Devoe
13.	10	Submerged Steel, Iron, or Concrete Surface	Coal-Tar Epoxy Two Component	ACRO 4467 Coal Tar Epoxy - ACRO Amercoat 78HB - Ameron Bitumastic 300M - Carboline
14.	16	Buried Steel or Iron	Tar-Base Pitch	ACRO 8500 Heavy Duty Coal Tar - ACRO Bitumastic No. 50 - Kop-Coat Devtar 247 - ICI Devoe
15.	0.4	Galvanized Metal Primer	Vinyl Wash Primer	ACRO 1162 Vinyl Wash Primer - ACRO Galva-Prep - Ameron Rustbond Penetrating Sealer - Carboline Devran 205 - ICI Devoe
16.	3.0	Steel Above Ground & Above Waterline	High Ratio Silicate Inorganic Zinc	ACRO 5502 Inorganic Zinc - ACRO Dimetcote 9 - Ameron V13-F-12 Inorganic Zinc - Valspar Catha-Coat 302H - ICI Devoe
17.	2.5	Steel Interior	Polyamide Cured Epoxy Resin	ACRO 4460 Chemical Resistant Epoxy - ACRO Amercoat 385 - Ameron Carboguard 561 - Carboline Bar-Rust 231, Devran 224HS - ICI Devoe
18.	2.0	Intermediate Finish		ACRO 4460 Chemical Resistant Epoxy - ACRO Amercoat 385 - Ameron Carboguard 561 - Carboline Devran 220 - ICI Devoe
19.	NA	Texture	Emulsion	Ready-Mixed Texture Compound - U.S.Gypsum Speedhide Texture Emulsion - PPG
20.	1.2	Sealer	Vinyl-Latex	Quick-Drying Latex Sealer, 6-2 - PPG Interior Vinyl Latex Primer-Sealer, 50801 - Devoe
21.	1.4	Finish Coat-Flat	Synthetic Alkyd Resin	Alkyd Flat Wall Enamel - Negley Speedhide Alkyd Flat, 6 Line - PPG 50801 - Devoe
22.	1.4	Finish Coat Semi-Gloss	Synthetic Alkyd Resin	Coronado Supercoat 5000 Speedhide Alkyd Lo-Sheen Enamel, 6 Line - PPG Velour Interior Alkyd Semi-Gloss Enamel - 26XX Devoe
23.	NA	Wood Filler	Alkyd Resin w/Linseed Oil	Paste Wood Filler - Negley Natural Paste Wood Filler - PPG Interior Solvent Base Paste Wood Filler 4800 - Devoe

TABLE 2 – COATING SCHEDULE

Symbol	Min. Dry Mils Per Coat*	Service	Generic Type	Brand and Manufacturer
24.	NA	Stain	Synthetic Alkyd Resin	Coronado Quick Seal Rez Interior Wiping Stain, Alkyd Oil Type, Quick Drying, 77-302 - PPG Penchrome DF203 - ICI Devoe
25.	1.0	Sealer/Primer	Synthetic Alkyd Resin	Rez Sealer-Primer, 77-1 - PPG
26.	1.5	Clear Finish, Satin	Polyurethane Varnish	Coronado Polyurethane 67 Series Rez Polyurethane Satin Clear Plastic Varnish, 77-89 - PPG DF500 - ICI Devoe
27.	1.5	Clear Finish, Gloss	Polyurethane Varnish	Coronado Polyurethane 67-10 Rez Exterior/Interior Polyurethane Gloss Clear Plastic Varnish, 77-55 - PPG
28.	5	Steel, Iron or Concrete Surface	Modified Amine-Addnet Epoxy	Polybrid 670S - Polybrid Coatings, Inc. (no “or equal”)
29.	40-120	Steel, Iron or Concrete Surface	Elastomeric Polyurethane Aromatic	Polybrid 705 - Polybrid Coatings, Inc. (no “or equal”)

*Or manufacturer’s standard, whichever is greater. Do not exceed manufacturer’s maximum standard, if applicable.
**For potable water use.

END OF SECTION

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SECTION 11304

DRY PIT SOLIDS HANDLING PUMPS AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the furnishing and installation of solids handling pumps and appurtenances as specified herein and as shown on PLANS. Existing pump motors are to remain and are not proposed for replacement.

1.02 RELATED REQUIREMENTS

A. PLANS show general arrangement, location, and basic dimensions. "Attachment A" to this Section designates performance and design requirements.

B. Related work as called for on PLANS or specified elsewhere in this or other TECHNICAL SPECIFICATION Sections.

1.03 REFERENCES

The latest version of 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.

AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM)

ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A48	Standard Specification for Gray Iron Castings
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A478	Standard Specification for Chromium-Nickel Stainless Steel Weaving and Knitting Wire
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM A743	Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5-2009	Pipe Flanges and Flanged Fittings

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings

AMERICAN NATIONAL STANDARD INSTITUTE/HYDRAULIC INSTITUTE (ANSI/HI)

ANSI/HI 1.1-1.2	Rotodynamic (Centrifugal) Pumps for Nomenclature and Definitions

ANSI/HI 1.3	Rotodynamic (Centrifugal) Pumps for Design and Application
ANSI/HI 1.4	Rotodynamic (Centrifugal) Pumps for Manuals Describing Installation, Operation and Maintenance
ANSI/HI 14.6	Rotodynamic Pumps for Hydraulic Performance Acceptance Tests
ANSI/HI 9.6.4	Rotodynamic (Centrifugal and Vertical) Pumps for Vibration Measurements and Allowable Values
ANSI/HI 9.6.6	Rotodynamic Pumps for Pump Piping

1.04 (NOT USED)

1.05 DESIGN AND PERFORMANCE CRITERIA

A. The pump shall be solids handling radial or mixed flow single-stage, centrifugal pump with horizontal suction and vertical discharge driven by existing horizontal motor. Provide pump, coupling, and coupling guard on a common structural steel base plate with existing motor. Accessories shall be furnished as required for a complete functioning pumping unit in accordance with the specified performance and installation conditions.

B. Pumps normally operate with a flooded suction. Under certain conditions pumps will operate with a negative pressure in the suction line as specified in Attachment “A”.

C. Rotation shall be suitable for existing motors.

D. The Contractor/pump manufacturer shall provide the design and construction drawings of the structural steel base and motor mount as required for the selected pump sealed by a licensed professional engineer in the State of Texas. At Contractor’s choice the existing motor mounts can be reused or new motor mounts can be provided.

E. The design requirements for the pumps shall be as follows:
   1. Design requirements for the pumps shall be as specified in Attachment “A” at the end of this Specification Section.
   2. The pumps shall be driven by existing motors.
   3. Critical speed analysis: The Contractor shall require that the pump manufacturer perform critical speed analyses for the pumping assembly to identify and ensure that:
      a. The first critical speed shall be at least 25 percent above the maximum pump speed;
      b. Any blade excited resonant frequency shall be no closer than plus or minus 25 percent of the natural frequency of any part of the installed assembled pumping unit.
   4. Allowable Operating Range: The Contractor shall require that pump manufacturer identify the allowable operating region of the pump curves submitted. When the allowable operating region is limited by a factor other than vibration, that factor shall be submitted to the Engineer as part of the Shop Drawings.

F. Seismic requirements:
   1. The Contractor shall conform to the requirements of Seismic Design Data shown on Drawings.

G. Equipment limitations:
   1. Proposed pumps shall be driven by the existing motors. Maximum brake horsepower of proposed pumps shall not be greater than horsepower rating of

existing motors under any condition of operation specified and indicated without operating in the motor service factor

2. Design equipment so parts are readily accessible for inspection and repairs, easily duplicated and replaced, and suitable for service as required.
3. Equipment shall be free from shock, vibration, and noise under load conditions.
4. Bearings and similar parts shall have temperature rise not exceeding limit of safety and good practice for such parts.

1.06 SUBMITTALS

A. Submit the following in accordance with Specification Sections 01300 “Submittals” and Specification Section 01730 “Operation and Maintenance Data”.

B. Shop Drawings

1. Equipment specifications and data sheets, with identification of all materials used and methods of fabrication. Designate materials by ASTM standards.
2. Complete assembly, layout, cross section, installation and shop drawings, with clearly marked dimensions submitted in electronic format.
3. Weights of equipment component parts, assembled weight of equipment, and total shipping weight. As applicable, include dynamic loads and weight when full.
4. Manufacturer’s product data, specifications and color charts for shop painting.
5. Provide a scaled drawing showing the pump, motor, hoist and bridge crane (by others) hook height limit, including equipment weights, lifting attachments and clearances for equipment removal and maintenance.
6. Pre-test pump curves on which the specified operating points are marked. Show efficiency and brake horsepower for the selected pump curve. Show required NPSH.
    a. For units of same size and type, provide curves for a single unit only.
    b. Include Allowable Operating Range (AOR) and Preferred Operating Range (POR) as defined by Hydraulic Institute.
    c. Assure that no operating points are outside of the parameters in Attachment A. As a minimum, no operating points should be outside of the AOR. Include HvsQ and BHP@1.0 s.g. curves from 0 gpm to runout gpm.
7. Tabulated Data: Rated head, capacity, NPSH and brake horsepower. Rated operated speed.
8. Submit speed-torque characteristic of pump. Include pump inertia. Submit certificate that the existing motors are suitable to drive the proposed pumps. Include a four-quadrant curve and show that reverse speed of pump at a power failure is within the acceptable limits set by the motor OEM.
9. Bearing temperature operating range for the service conditions specified.
10. Bearing life calculations certified by pump manufacturer.
11. Tests will be witnessed. Submit certified shop test procedures, the equipment to be used, plan and section drawings of the testing arrangements and manufacturer’s sample form for reporting performance test results at least two weeks before the tests. The test shall conform to ANSI/HI 14.6, Grade 1U.
12. Certified performance curves showing pumping head, capacity, horsepower and efficiency from shut-off to beyond minimum operating head at operating speed. In addition, include $NPSH_R$ curves. The $NPSH_R$ curve shall extend from the Allowable Operating Range limits as defined by Hydraulic Institute Standards.
13. Testing procedure and balancing report for the balancing of the impeller and all shafts. Both static and dynamic balancing shall be completed. Certified results of dynamic balancing (prior to shipping).

14. Submit certified performance curves at least two weeks prior to shipping the units from the factory. Provide copies of the data recorded during the test and methods of data reduction for determining certified tests results.
15. Field test procedure.
16. Manufacturer's delivery, storage, and handling requirements.
17. Manufacturer's installation instructions and recommendations.
18. Certified statement of pump, motor and shafting laser alignment are within manufacturer's tolerances.
19. Certified setting plans, with tolerances, for anchor bolts.
20. List of recommended spare parts other than those specified. Spare parts list to indicate sizes, quantities, and part numbers of the items to be furnished, including any special tools required for assembly/disassembly of Pump Unit.

C. Operation and Maintenance Manuals shall conform to the requirements of Specification Section 01730 "Operation and Maintenance Data".

D. Certificates:
1. Metallurgical certificate from foundry for all castings of pump components, including but not limited to: casing, front head, bearing frame, impeller and shafts.
2. Machining accuracy certificate showing that shaft fabrications were machined within OEM drawing tolerances.
3. Material Certification:
   a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials others than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to Owner.
   b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
4. Certification of welders in accordance with American Welding Society (AWS).
5. Certification that the centrifugal pump is compatible with the existing pump motor based on pump manufacturer's review of technical data for the existing motor.
6. Certified statement of pump, motor and shafting laser alignment are within manufacturer's tolerances.

E. Reports:
1. Certified report of Resonant Frequency Analysis. Pump manufacturer shall provide whatever devices or supports necessary to meet the requirements of the analysis, at no additional cost to the Owner.
2. Factory Tests: Furnish reports of witnessed and certified factory tests. No equipment shall be shipped from its place of manufacture before the witnessed and certified factory test reports have been approved by the Engineer.
3. Field Tests: Furnish reports of field tests. Prior notification of field tests shall be submitted for all equipment at least two weeks before the tests.
4. Installation Report: Furnish to ENGINEER copies of certified report prepared by manufacturer's technical representative certifying satisfactory installation, operation, and in service placement of units. Include certified statement of pump, motor and shafting alignment are within manufacturer's tolerances.
5. Additional reports requirements: as required by 1.07.C and elsewhere in this Specification.

1.07 QUALITY ASSURANCE

A. System Coordination:
   1. CONTRACTOR retains overall responsibility to properly install, adjust, test, and place in operation the Pump Units.
   2. The pump manufacturer shall furnish the pumps to be driven by existing motor to insure proper coordination, compatibility, and operation of the system.
   3. Pumps shall be manufacturer's standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.

B. Manufacturer's Qualifications
   1. The Contractor shall provide evidence to the Engineer that the manufacturer has a minimum of five (5) years of experience, within the last ten (10) years, in the design, manufacture, and supervision of installation of equipment of the type and size specified (or larger) under this Specification.
   2. The Contractor shall provide evidence to the Engineer that equipment which was designed and manufactured by the manufacturer, and which is similar to the equipment required under this Specification, has been in continuous and successful operation in at least five (5) separate facilities for the past five (5) years.

C. Manufacturer's representative
   1. Furnish services and training required in Section 01445, "Manufacturers Field Services" unless otherwise specified in this Specification Section.
   2. The Contractor shall provide the services of a qualified manufacturer's service technician to:
      a. Supervise the installation of the equipment;
      b. Check the installation before the equipment is placed into operation;
      c. Assist in the performance of field tests;
      d. Assist in start-up of equipment; and
      e. Train the plant operations and maintenance staff in the care, operation and maintenance of equipment.
   3. The Contractor shall provide the services of the manufacturer's service technician at such times and for such duration of time as are needed to perform the tasks required of the representative as specified in Article 1.07.C.2 above. At a minimum, the services of the manufacturer's technician shall be provided as indicated herein below and any additional time required shall be provided at no additional cost to the Owner. The number of visits and person-days per visit indicated below shall be understood as referring to the total required services for the lot of equipment provided under this Specification.

a.	Installation:	3	visits of	3	person-days per visit
b.	Field testing:	3	visits of	3	person-days per visit
c.	Start-up:	1	visits of	5	person-days per visit
d.	Training:	4	visits of	1	person-days per visit

   4. The Engineer reserves the right to require that any unused person-days from any visit be applied to any other specific visit.
   5. Person-days shall be understood only as days spent on-site (not in transit).
   6. Unless otherwise authorized by the Engineer, the manufacturer's technician shall be a direct employee of the equipment manufacturer or a factory trained technician, with at least five (5) years of experience in the installation, testing and start-up of equipment of the type provided under this Specification. Provide resume of the proposed manufacturer's technician for engineer approval before commencing of work. The manufacturer's sales and marketing personnel will not be accepted as manufacturer's technicians.

7. Reports: The Contractor shall submit a report from the manufacturer for each visit to the Site of the manufacturer's technician. The report shall provide complete information regarding the visit, including, but not limited to, dates, times, subject equipment, tasks performed, persons contacted, problems corrected, test results, training provided, and other pertinent information.
8. In addition to the above, the Contractor shall provide the services of person(s) authorized by the manufacturer to witness the unloading at the Site and, if stored, placing into storage the equipment provided under this Specification, and to ascertain the condition of said equipment. Manufacturers' sales and marketing personnel may be accepted as authorized person(s) to perform these specific tasks. The Contractor shall submit to the Engineer a report, completed by the authorized person(s) and certified by the equipment manufacturer, documenting the findings of the authorized person(s).

D. Painting: The equipment provided under this Specification shall be shop cleaned, primed, and finish painted, and field painted in accordance with the requirement of Specification Section 09902 "Painting and protective coatings".

1.08 DELIVERY, STORAGE AND HANDLING

A. Manufacturer shall carefully prepare the pump for shipment to minimize the likelihood of damage during shipment. Cavities shall be drained of water. Equipment shall be properly supported and securely attached to skids. Openings shall be covered in a manner to protect both the opening and interior.

B. Deliver, unload, and store products on site in a manner that prevents damage. Use special care to prevent damage from temperature and condensation.

1.09 SPARE PARTS

A. For each pump size, provide spare parts that are identical to an interchangeable with similar parts installed.
1. One set of all pump shaft bearings.
2. One set of all special tools required.
3. One complete set of shaft sleeves.
4. One complete set of gaskets.
5. One complete set of wearing rings with fasteners.
6. One complete set of mechanical seals.

B. All spare parts shall be plainly tagged, marked for identification and reordering and shall be delivered properly boxed, and sealed in plastic bags to prevent damage and/or corrosion from dust, dirt and moisture.

PART 2 PRODUCTS

2.01 MANUFACTURER(S)

A. CornellFairbanks Nijhuis

C. Flowserve

D. Patterson Pump Company

E. Or, equal.

2.02 MATERIALS AND/OR EQUIPMENT

A. General

1. Pump units shall be suitable for pumping wastewater from Flow Equalization Basins to Flow Splitter Box at Secondary Treatment Units. Flow Equalization Basins follows primary settling tanks.
2. Pumps will be driven by existing motors. Characteristics of existing motors are provided in Attachment “B”. Operation and Maintenance manual for existing pump motors and motor mounts are available at the Plant upon request.
3. Pumping unit to yield performance stable and free from noise or vibration throughout operating range. From run-out head to shut-off head, the Head vs. Capacity curve shall be constantly rising without a 0 or reverse slope.
4. Pumps shall be manufactured in accordance with the latest Hydraulic Institute Standards and manufactured under the latest ISO-9001 series certification.
5. Pump shall operate within vibration and bearing temperature limits specified over the full operable range of the pump performance. Motors shall be non-overloading under any condition of operation specified and indicated without operating in the motor service factor.
6. Equip pumping units with all specified and required accessories, including lifting attachments, pressure gages and drain connections. Lifting attachments are defined as the rigging required to lift one motor or one pump at a time and transport the motor (or pump) to another position in the pump station.
7. Apply a never seize compound to all bolts.
8. Provide isolation sleeves and washers when stainless steel hardware is used on dissimilar materials.
9. The pumps shall be capable of temporary operation at or near shut off head for two (2) minutes to allow for opening and closing of the pump discharge control valve as the pump starts or stops.
10. If proposed equipment required modification of exiting conditions other than those shown on drawings provide all structural, architectural, mechanical, electrical and plumbing revisions at no additional cost to the Owner
11. Coordinate pump dimensions and weights with the existing hoists and bridge cranes located on site.
12. Pumps to be able to accommodate reverse flow.

B. Casing

1. The casing shall be made of close-grained cast iron conforming to ASTM A48 CL30 minimum or ductile iron conforming to ASTM A536 Gr 65-45-12
2. Casing shall withstand a hydrostatic test of 150% of shut-off head or 200% of the head at the rated condition, whichever is greater.
3. Provide casings designed for removal of rotating parts without disconnecting suction and/or discharge piping.
4. Provide lifting devices on casings for handling.
5. Face and drill flanges of suction and discharge connections in accordance with ANSI/ASME B16.1 Class 125.
6. Provide components with machined registered concentric shoulder fits for precision alignment. Equipment without registered fits is not acceptable.
7. Provide air valve assembly to be installed on the highest point of the casing. The air valve shall be an air and vacuum valve designed for sewage.
8. Provide low point of casing with a minimum 3/4-inch drain.
9. Pumps with splitter vanes in casing are not acceptable unless specifically indicated in the Process Pump Schedule.
10. Provide pump feet designed for the following additional forces:
    a. Hydraulic thrust equivalent to two times the shut-off head times the area of the discharge nozzle and acting at centerline of the discharge nozzle.

C. Main Frame:
1. Cast iron ASTM A48 Class 30 minimum.
2. Fit to casing with machined registered joints.
3. Provide main frame designed to resist without distortion, all stresses due to impeller thrust and bearing loads.
4. Provide main frame designed to support shaft and impeller and to contain stuffing box and bearings.

D. Impeller
1. Type: Enclosed radial or mixed flow solids handling single suction.
2. Impeller shall be close-grained cast iron conforming to ASTM A48 CL30, enclosed multi vane, non-clog.
3. Provide a keyed impeller to shaft connection by a streamlined bolt or locknut capable of holding in event of motor reversal under full torque.
   a. Impeller Fasteners: Type 416 stainless steel Impellers shall be secured to the shaft through a precision fit and full-length key
4. The impeller shall be statically and dynamically balanced to a precision balance grade of ISO 2.5.
5. Provide vanes having wide suction and waterways that will pass solids and stringy without clogging.
6. Provide pumps capable of passing a minimum solid sphere size of 3 inches.
   a. Pumps capable of only passing a deformable sphere are not acceptable.
7. Impellers shall be precision cast in one piece with smooth flow contours to promote maximum efficiency.
8. The impeller shall have face type impeller wear rings specified elsewhere.
9. Provide a means of adjustment of wearing ring clearance.

E. Shaft
1. The pump shaft shall be forged steel in accordance with ASTM A434 GR 4140-4142 or approved equal.
2. The pump shaft shall be precision machined to a smooth finish over the entire length with appropriate grinding and polishing at bearing areas, and free from harmful and damaging vibrations.
3. Seal areas and bearing journals subject to wear and corrosion shall be fitted with replaceable stainless steel sleeves conforming to ASTM A487 Grade CA-15 stainless steel with 325-400 BHN or approved equal.
4. The sleeves shall be positively sealed to prevent contamination from pumpage or external liquids, and shall be positively driven with a key.
5. Shaft diameter shall be sized to prevent torsional deflection, flexural deflection, whipping and vibrating. Shaft will be of sufficient size to transmit the full driver horsepower with a minimum of 2.0 safety factor.
6. Shaft shall be manufactured to meet stiff shaft construction with a critical speed at least 25% in excess of actual maximum operating speed, in order to prevent vibration and fatigue.
7. Shaft shall be accurately machined along its entire length. A keyway shall be machined at the coupling end.
8. Provide Teflon (PTFE) or Viton (FKM) gaskets or O-rings to prevent leakage between shaft and sleeves.

F. Bearings
1. Anti-friction, oil lubricated bearings for both the inboard and outboard ends of the pump.
2. Outboard bearing to be combination thrust and radial type; inboard bearing radial type.

3. Provide bearings with minimum B-10 life rating of 100,000 hours at specified operating conditions and 40,000 hours minimum at 25 percent of the BEP at highest speed, based on latest ABMA and ANSI Standards.
4. Bearings shall be of standard sizes to ensure interchangeability and accessible for easy replacement.
5. Anti-friction bearings shall be roller or ball type and oil lubricated.
6. The bearing assembly shall be engineered to adjust the rotating assembly axially, without pump or bearing disassembly
7. For each bearing, furnish and install:
    a. Sight glass
    b. Oil reservoir
    c. Oil fill and drain connection, including fill line filter and cap and drain valve and plug.
    d. Trico oiler
8. Provide provisions for installation of bearing temperature and vibrations monitoring sensors.
9. Seal bearing housings with a static and dynamic sealing device at each shaft exit similar to the Inpro-seal or Bearing Gard.

G. Wear Rings
1. Wear rings shall be provided on both the impeller and front-head so that clearances can be maintained throughout the life of the rings and minimize recirculation.
2. Removable, made of material that will resist corrosion and erosion.
    a. Impeller: Stainless Steel ASTM A487 Grade CA-15 with a 300 to 350 BHN.
    b. Casing Wearing Rings: Stainless Steel ASTM A743/A743M Grade CA-40 with a 400 to 450 BHN.
3. Securely fastened to prevent any relative motion and designed for easy replacement.

H. Sealing Box
1. Split mechanical seals manufactured by Chesterton, Style 442 with SpiralTrac Version F Type S or approved equal.
2. All components of the seal shall be split in half including the elastomers, gland, rotary and stationary seal faces and rotary holder.
    a. The seal shall be able to be installed outside of the stuffing box without any equipment disassembly required.
    b. Hydraulically balanced design to provide maximum interchangeability without equipment modification.
    c. The stationary seal face shall be mechanically loaded with multiple springs to ensure no leakage when the pump is shut off. The springs shall be isolated from the pumped product in order to eliminate potential corrosion or clogging problems.
    d. The gland halves shall have an interlock mechanism to prevent distortion at the gland halves.
    e. The seal shall be capable of sealing 80 psig at maximum pump speed.
3. Materials:
    a. Gland: Type 316 stainless steel
    b. Rotary holder: Type 316 stainless steel
    c. Hardware: Type 316 stainless steel
    d. Springs: Hastelloy C or Elgiloy
    e. Rotating Faces: Silicone Carbide
    f. Stationary Faces: Silicone Carbide
    g. Elastomers: Viton
    h. Restriction Bushing: Split type, glass filled teflon

I. Handhole Cleanouts:
   1. Locate handholes in discharge nozzle of volute and in suction elbow or fronthead for vertically mounted pumps and fronthead of horizontal pumps to provide access to impeller and interior parts.
   2. Equip handholes with covers designed for easy removal.
   3. Shape interior surface of cover to maintain contour of interior of casing or elbow to which it is attached to maintain efficiency and to prevent lodging of solids.
   4. Gaskets: Neoprene or Buna-N.
   5. Hardware: Type 316 Stainless Steel.

J. Baseplate
   1. The Contractor shall provide and embed the anchor bolts for securing the pump/motor base plate to the foundation pad. Other bolting and shimming material and all other appurtenances shall be furnished by the Contractor for a complete installation of the pumping unit baseplate. Anchor bolts shall be designed for a minimum of 2 times the maximum expected load or higher if recommended by the pump manufacturer. Anchor bolt sizing calculations, sized for the applicable Seismic zone, and signed and stamped by a Professional Engineer registered in the state of Texas shall be provided by the Pump Manufacturer as part of the product data submittal.
   2. Mount pump and driver on common structural steel base designed to withstand deflections due to hydraulic loads or motor torque and to support pump and motor in proper alignment and prevent harmful or damaging vibrations.
   3. Provide motor base for welding to baseplate if alignment of the new pump do not accommodate the use of existing motor mount. Field machine motor base parallel with baseplate machined surfaces.
   4. Bent form bases are not acceptable. Provide a structural steel baseplate that has been thermally stress relieved prior to machining.
   5. Material: ASTM A36 fabricated structural steel.
   6. Provide with provisions for grouting, for anchor bolts and to collect leakage.
   7. Machined mounting surface shall be coplanar to 0.002” per foot of span, and shall extend 2” beyond pump and driver feet on all sides
   8. After leveling and alignment, the base shall be grouted and completely filled with a non-shrinking grout per manufacturer recommendations.
   9. A flexible coupling and an enclosed type coupling guard shall be provided.

K. Couplings:
   1. Type: flanged sleeve double engagement
   2. Manufacturer: Rexnord
      a. Model: Falk Lifelign G20 or G32

L. Vibrations Monitoring:
   1. Project includes use of existing vibration transmitter on the proposed pumps.
      a. Existing vibration transmitter is manufactured by Metrix model S5484E-121-2-1-0-0-0 installed circa 2014. Vibration transmitter is equipped with a 3/8-24 UNF x 1/2 inch mounting stud.
   2. Provide pump with drilled and tapped hole at bearing house for mounting of existing vibration transmitter.

M. Drain, Vent and Seal Water Piping:
   1. Provide drains from stuffing box and casing vent and drain piping and valves to discharge into existing gutters or sumps.
   2. Provide seal water piping, valves and accessories at pump as specified and indicated.
   3. Drain and vent piping: Schedule 5 Type 316L stainless steel with Pressfit connections or Schedule 40 Type 316L stainless steel with socket welded

connections. Provide a sufficient number of unions to permit removal of each valve and in-line device.

4. Seal water piping: 1/2" stainless steel tubing with compression fittings. Provide a sufficient number of unions to permit removal of each valve and in-line device.
5. API Plan 32 seal vent piping. as shown on PLANs.
6. Provide pipe and fittings in accordance with Section 15255 and as indicated.
7. Valves: Provide size and type as indicated and in accordance with Section 15100.

N. Painting: Per Specification Section 09902, "Painting and Protective Coatings" as follows:
1. Shop painting: Factory applied Primer and Finish Paint
2. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating
3. Provide additional shop paint coating for touch-up to all surfaces after shop testing is completed and equipment accepted.
4. During installation and after approved testing by the Engineer, apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.

2.03 SOURCE QUALITY CONTROL

A. Shop Tests:
1. All of the shop tests required under this Specification shall, in addition to being certified by the manufacturer, be witnessed by the Owner's representatives. Provide a minimum of 30 days written notice to the Engineer prior to shop testing.
2. Coating of the impeller with any product to raise the hydraulic efficiency shall not count toward meeting the hydraulic efficiency requirement.
3. Certified shop tests shall be performed for all equipment provided under this Specification. Standard performance test will be conducted as specified in ANSI/HI 14.6 for Centrifugal Pump Tests Grade 1U, and all test data shall be submitted for approval by the Engineer prior to shipment. Test and record speed, flow, head, and horsepower. Certified copies of the calculated anticipated pump field performance curves shall be submitted, including head, capacity, efficiency, total brake horsepower, NPSH and required submergence.
4. Hydrostatic Testing: Each pump rotating assembly and pump casing shall be hydrostatically tested at not less than the greater of the following, and in full compliance with the ANSI/HI 14.6:
    a. 200% of the pressure which would occur when the pump is operating at the rated condition of the pump or,
    b. 150% of the pressure which occur when the pump is operating at rated speed against a closed discharge valve.
5. Run pump at full speed rating point for 60 minutes prior to start of any testing.
6. Performance of the pumping units shall be within the tolerances acceptance grade of 1U, as specified in ANSI/HI 14.6, when operated at design speed and capacity (Rating Point in Pump Schedule attached as Appendix "A").
7. Full speed tests:
    a. Test pump at the conditions specified and indicated and take no less than seven operating points between shutoff and runout. Test conditions must be at the conditions specified and indicated.
    b. Take readings to determine flow, differential pressure, rpm, horsepower and efficiency
    c. Operate pump for not less than one hour and take readings to determine that the pump will operate as specified and indicated without cavitation at the specified minimum head condition with not more than the specified NPSH available.

8. All instruments, meters and other measurement devices used during the tests shall be within their calibration period. Copies of the certificates of calibration shall be submitted to the Owner's representative prior to witnessing the tests.
9. In the event that specified tests indicate that pump will not meet specifications, Engineer has the right to require additional complete witnessed tests for all pumps at no additional cost to the Owner, reject the unit, or accept the unit at a reduced price.
10. Repeat tests until specified results are obtained. If impellers are trimmed or modifications made to the pumps, pump assemblies must be retested.
11. Correct or replace promptly all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.
12. Factory tests as outlined above shall be witnessed by the Owner's representatives. The manufacturer shall include cost for no more than two (2) factory trips, each trip attended by four (4) Owner's representatives, per factory trip, and for a duration of up to 5-standard business days per factory trip, and ten (10) standard business hours per business day. The cost of meals and incidental expenses during each trip shall be Owner's responsibility.
13. In the event that testing of the pumps cannot be completed in the time specified above, the Contractor shall bear cost for additional factory trip for witness testing at no additional cost to the Owner.
14. Prior tests on similar or identical pumps are not acceptable.
15. The test lab shall use a shop calibrated motor for each size to drive the pumps.

PART 3 EXECUTION

3.01 - 3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Installation of equipment and materials provided under this Specification Section shall be in accordance with the manufacturer's recommendations and the approved shop drawings.

B. Install pumping units on a concrete pad and align thereon.
1. Align and level pumping unit to motor and coupling. Use precision levels and gauges. Final alignment to utilize a laser-type shaft alignment system performed in presence of OWNER.
2. Coupling halves must be disconnected and only reconnected after alignment.
3. Set base on stainless steel shims placed directly under the part of the base carrying the greatest weight and spaced close enough to provide uniform support.
4. Dowel pump and drive to baseplate after alignment in field to facilitate realignment after disassembly.

C. After installation of pump equipment, bring piping into direct axial alignment with pump discharge. Flange faces shall fit closely and squarely. The pump suction and discharge shall have no strain imposed upon it by piping misalignment.

D. Test piping connections, to prove the pump nozzles are installed with the pipe in a free supported state without need to apply vertical or horizontal pressure to align piping with pump nozzles, by removing all flange bolts and checking flange to flange alignment.

E. Final Coupling Alignment:
1. Perform only after base is installed and piping is connected and pump nozzle connections tested in accordance with paragraph 3.03.D.

2. If realignment is required piping must be disconnected prior to alignment, piping reconnected and alignment checked prior to connecting coupling halves.
3. After alignment is correct, grout using high grade non-shrink grout, fill entire base and leave no gaps or voids. Do not imbed leveling nuts in grout.

F. Special Precautions: Before starting the pumps the Contractor to check the following:
1. Check that pump rotating elements are free
2. Check rotation of motor with pump drive disconnected.
3. Check settings of the pumps control valve

G. After start-up and testing as specified below, shut down pump and recheck alignment of coupling using laser alignment tools. Check in all directions and follow manufacturer's instructions.

H. After unit has been operated within the allowable operating range for one week, check couplings for misalignment and correct as necessary using laser alignment tools.

I. After completion of all procedures specified above, clean and touch up any damaged coating system as required.

3.04 REPAIR/RESTORATION (NOT USED)

3.05 FIELD QUALITY CONTROL

A. Provide a minimum of 30 days written notice to the Engineer prior to field testing.

B. After installation of pumping equipment, and after inspection, operation, testing and adjustment have been completed by the Contractor, and supervised/inspected by the manufacturer's technical representative, conduct running test for each individual pump system in the presence of Engineer to determine the ability of the pumps, motors, pump control valves and instrumentation to operate like a coordinated system. Check each individual pump system's ability to operate within vibration and temperature limits specified, and to deliver its rated capacity under specified conditions.

C. Vibration tests to prove that there are no field installed resonant conditions due to misalignment or the connecting piping and its supports.

D. During tests, observe and record head, capacity, motor inputs, noise, vibration, pump bearing house and motor bearing temperature.

E. Promptly correct or replace all defects or defective equipment revealed by or noted during tests, at no additional cost to the Owner, and repeat tests until specified results that are acceptable to the Engineer are obtained. Contractor shall provide labor, material, equipment, and piping for conducting tests.

F. Provide vibration signature testing in accordance with ANSI/HI 9.6.4-2016, Centrifugal and Vertical Pump for Vibration Measurements and Allowable Values, except as modified herein:
1. Vibration readings, shall not exceed 0.16-in./sec. RMS, unfiltered
2. Submit written report with analysis conclusion, exhibits of where measurements were made, etc. Report shall contain complete analysis of findings, problems encountered, if any, and probable cause and specific recommendations for any corrective action.

G. Test Duration: The tests shall be conducted for a continuous period of 2 hours minimum at each speed, or until bearing temperatures are constant for 3 consecutive readings (whichever is longer) at each condition specified and indicated.

H. Contractor to provide all equipment, flow meters and test gauges for conducting tests.
   1. Contractor shall provide calibrated test gauges for all permanently installed gauges and portable calibrated flow meters for all pumping systems.
   2. All calibrations must be within 30 days of the field testing.
   3. The testing will not be started and will not be accepted until the calibrated testing equipment stated above is operational and all certifications have been submitted.

I. Water for testing can be settled wastewater from existing Flow Equalization Basins (FEBs), and can be returned to splitter box ahead of Aeration Basins. Reference Specification Section 01046 “Sequence of Construction” for additional details on using settled wastewater for testing.

J. If required, take corrective action and have the Pump Units retested to ensure full compliance with the specified requirements. Remove and replace equipment at no additional cost to the Owner with equipment that will meet all requirements specified and indicated if unable to demonstrate to the Engineer that units will perform the service specified and indicated. All costs associated with the field tests or any required corrective action shall be borne by the Contractor.

K. The vibration analysis indicated above shall be repeated 6 months after signature testing, in the presence of Engineer and Owner. A report shall be prepared comparing the results of the 6-month tests with the results of the signature tests. Significant worsening of the vibration, to be determined by the ENGINEER, during the 6-month tests shall require corrective action and retesting.

L. Operation Test:
   1. Operation Test is required to be completed for each pumping unit before additional unit can be removed from service.
   2. The Operation Test shall be conducted for seven (7) continuous calendar days. The operating time for the pump in each day shall be no less than four (4) continuous hours. During test, observe and record head, capacity (if possible), motor inputs, noise and vibration. Promptly correct or replace all defects or defective items revealed by or noted during test, at no additional cost to the OWNER, and repeat test until specified results that are acceptable to the Engineer are obtained.
   3. After the Operation Test, re-check coupling alignment within specifications.
   4. Provide certified field measured performance curves showing conformance of pump with original factory provided test curves.
      a. Show pumping head, capacity, horsepower, and efficiency from shutoff to minimum operating head at operating speed and brake horsepower.
      b. Acceptance of field certified curves by the OWNER will be required prior to payment.

3.06 ADJUSTING

A. Manufacturer’s technical representative to inspect, check, assist in making adjustments if necessary, and approve for placing in operation.

3.07 - 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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.

ATTACHMENT A

PROCESS PUMP SCHEDULE

Parameter	Pump Requirements	
Pump Identification	Settled Wastewater	Settled Wastewater
Number of Unit(s):	5	3
Pumping Unit(s) Designation:	OP-SWP-001 OP-SWP-002 OP-SWP-003 OP-SWP-004 OP-SWP-005	OP-SWP-006 OP-SWP-007 OP-SWP-008
Type of Service	Wastewater	Wastewater
Pumping Unit Drivers:	Solid Shaft Electric Motor	Solid Shaft Electric Motor
Location	Operations Bldg	Operations Bldg
Water Temperature	35°F-85°F	35°F-85°F
Minimum Suction Size (inch)	30	20
Maximum Suction Size (inch)	36	30
Minimum Discharge Size (inch)	24	20
Maximum Discharge Size (inch)	30	36
Primary Rating Point at Full Speed: Pumping Capacity (gpm) Pumping Head (FT) Minimum Bowl Efficiency	 27,000 58.0 85%	 9,720 50.0 81.5%
Secondary Rating Point at Full Speed: Pumping Capacity (GPM) Pumping Head (FT) Minimum Pump Efficiency	 21,600 70.0 79.5%	 15,000 28.0 74.5%
MCSF (Minimum Constant Flow) Capacity (GPM) Head to exceed (FT)	 16,800 77.0	 7,500 55.0
Pump Full Speed (RPM)	505	590
Maximum Horsepower (HP)	500	200
Net Positive Suction Head Required (NPSHr) at first rating point not to exceed (ft)	23.0	30.0
Net Positive Suction Head Required (NPSHr) at run-out point not to exceed (ft)	29.0	-
Shutoff Head not to exceed (ft)	110	80
Run-out point Pump Head to be less than (ft)	33.5	-
System Suction Pressure - Minimum (PSI)	-4	-4
Pump capacity at 33.5 (FT) head to be less than (GPM)	39,000	N/A

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ATTACHMENT B

MOTOR DATA (EXISTING MOTORS)

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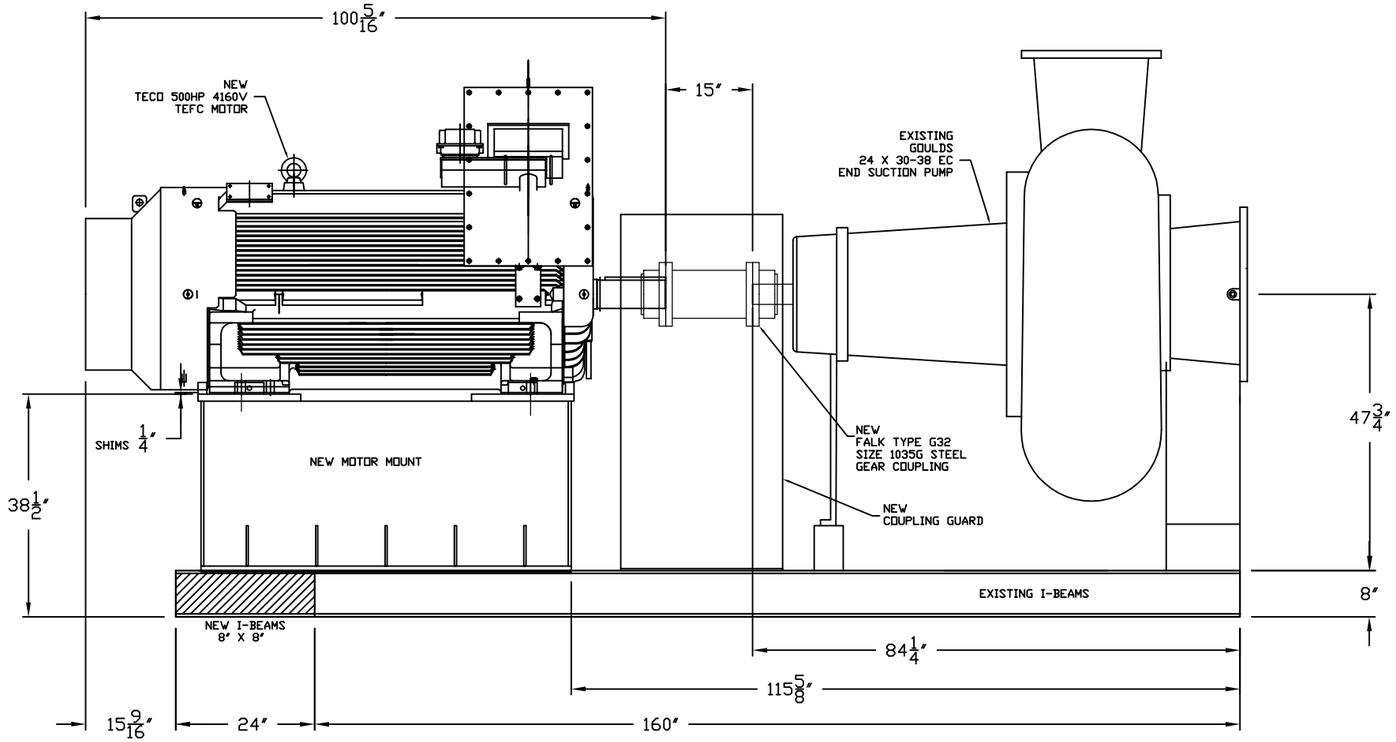
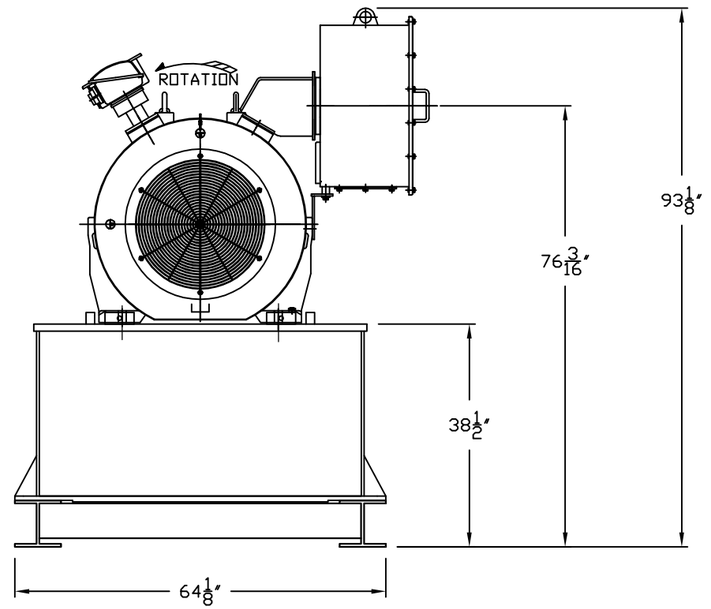
500 HP Motor Data

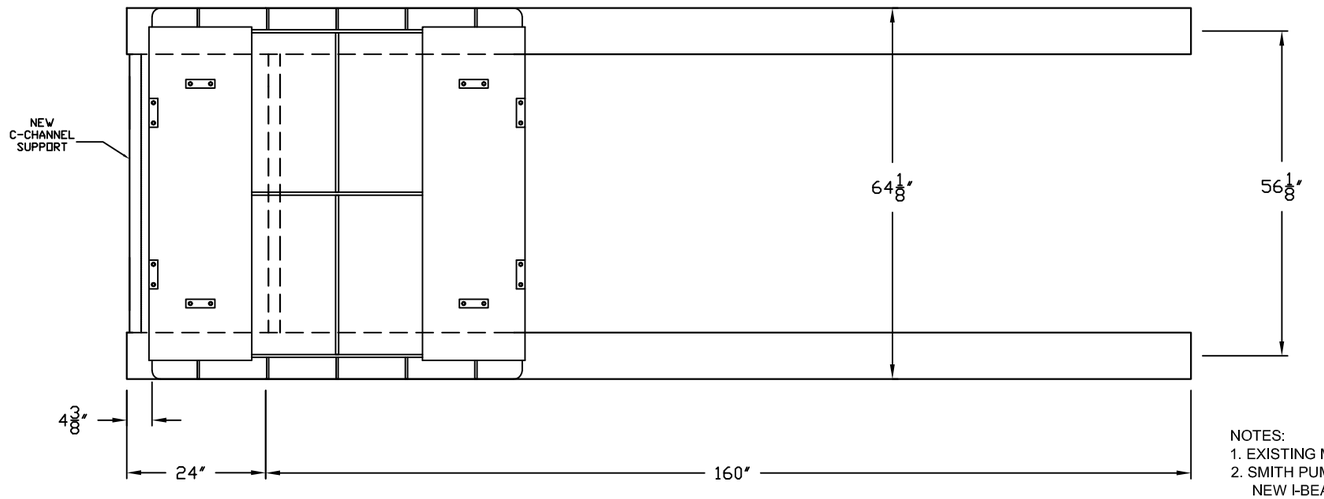
SPECIFICATION TABLE OF 3-PHASE SQUIRREL CAGE INDUCTION MOTOR	CUSTOMER		USER	
	INQ. NO.		EQUIPMENT	
	JOB NO.	FD13C021T1	MACHINE	
	TOTAL SETS	5	ITEM NO.	

Item	Terms	Description			
1	Model	AEHG-TK			
2	Code or Standard	Dimensions	Frame Assignment	Performance	Test
		NEMA	TWMC	NEMA	NEMA
3	Rating	500 HP 14 Pole 4160 Volt 3 Phase 60 Hz			
4	Service Duty	Continuous Rating , S.F. 1.15			
5	Starting Method	D.O.L. or Auto Transformer			
6	Rotation	Facing The Non Drive End : CCW			
7	Drive Method	Direct Coupling			
8	Environment	Amb. Temp. : -20 ~ 40 ℃			
		Humidity : Less Than 95 %RH			
		Altitude : Up to 3300 FT			
9	Enclosure & Protection	IP54 : Totally Enclosure			Indoor
10	Cooling	IC411 : Self External Fan, Surface Cooling			
11	Mounting	IM1001 : HS, Foot			
12	Dimensions	Dr# 3A040W356 (REV.02) Frame No ： 6810B			
13	Frame & Bracket	Frame : Cast Iron Bracket : Cast Iron			
14	Fan & Fan Cover	Fan :Aluminum Fan Cover :Steel Plate			
15	Terminal Box	Steel Plate			
16	Lead Terminals	(TLKF35-10)X3			
17	Lubricant	ESSO Polyrex EM Grease			
18	Painting	Color : MUNSELL 7.5B 3.5/0.5			
19	Stator Winding	Ins. Class F			
20	Rotor Conductor	Cu-Alloy			WK^2 ： 1718 Lb-ft^2
21	Starting Performance	LRC ≦ 435 Amp			LRT/FLT 110 %
22	Operating Performance	Hz/V	60/4160		Break Down Torque
		%Load	100	75	50	210 %FLT
		Amp.	78.1	64.4	53.7	
		Eff.%	94.0	93.5	91.0	Temp. Rise Limit. (Res.)
		P.F.%	70.5	64.5	53.0	Stator 80 ℃
		R.P.M.	507	509	511	at S.F.1.0
23	Approximate Weight	Motor ： 11000lb			
24	Note	1.With Space Heater : 1φ 120V 300W 2.With Winding RTD : PT 100Ω/0℃ 6pcs (Alarm 145℃ , Trip 155℃) 3.With Bearing RTD : PT 100Ω/0℃ 2pcs (Alarm 95℃ , Trip 100℃) 4.Noise : Below 85dBA at 3 Feet Distance No Load 5.Power Factor Can be Corrected to 95.0% With The Addition of 270KVAR Correction Capactiors(Recommended) 6.Bearing Life: 75000hr/B10 7.Vibration Level: Alarm 4.2mm/sec, Trip 7.0mm/sec 8.Re-lubricated Period: Every 3000 hrs			

APPD.	Ming	NOV. 18 2013	TECO Westinghouse	DWG NO. 3A057H186-72794
CHKD.	AIYU	NOV. 18 2013		REV.00
DWN.	Noel	NOV. 13 2013		1/2







NOTES:
1. EXISTING MOTOR MOUNTS, MOTORS, & COUPLINGS TO BE REMOVED BY CONTRACTOR
2. SMITH PUMP TO WELD 24" LONG I-BEAMS TO EXTEND BASE & INCLUDE C-CHANNEL SUPPORT, NEW I-BEAMS TO BE ANCHORED TO CONCRETE FLOOR BY CONTRACTOR
3. NEW MOTOR MOUNTS & MOTORS TO BE ALIGNED AT JOBSITE WITH NEW COUPLINGS, SHIM MOTOR AS REQUIRED.
4. NEW MOTOR MOUNT TO BE WELDED TO EXISTING I-BEAMS AFTER ALIGNMENT
5. MOTOR BOLT HOLES TO BE DRILLED IN NEW MOTOR MOUNT PADS AFTER ALIGNMENT
6. NEW MOTOR MOUNT TO BE FILLED WITH NON-SHRINK GROUT AT JOBSITE AFTER ALIGNMENT.
7. ALL BOLTS TO BE 18-8 STAINLESS STEEL.

REV	DATE	DESCRIPTION
A	5/21/12	SPCD PROVIDE I-BEAMS, WELD DOWN MOUNTS

UNLESS OTHERWISE SPECIFIED DIMINSIONS ARE IN INCHES
TOLERANCES

DECIMALS		ANGLES	
.X	+/-.1	NO DEC.	+/-2DEG
.XX	+/-.06	.X	+/-1.0 DEG
.XXX	+/-.030	.XX	+/-0.5 DEG
.XXXX	+/-.0015	.XXX	+/-0.250 DEG

FINISH ALL MACHINED SURFACES 250
BREAK ALL CORNERS AND SHARP EDGES .010/.030
RADIUS ALL FILLETS .015/.040 R
CHAMFER ALL THREADED HOLES 90/120 DEG
TO A DEPTH OF ONE THREAD +/- .030
SCREW THREAD STANDARDS PER FED-STD-H2B

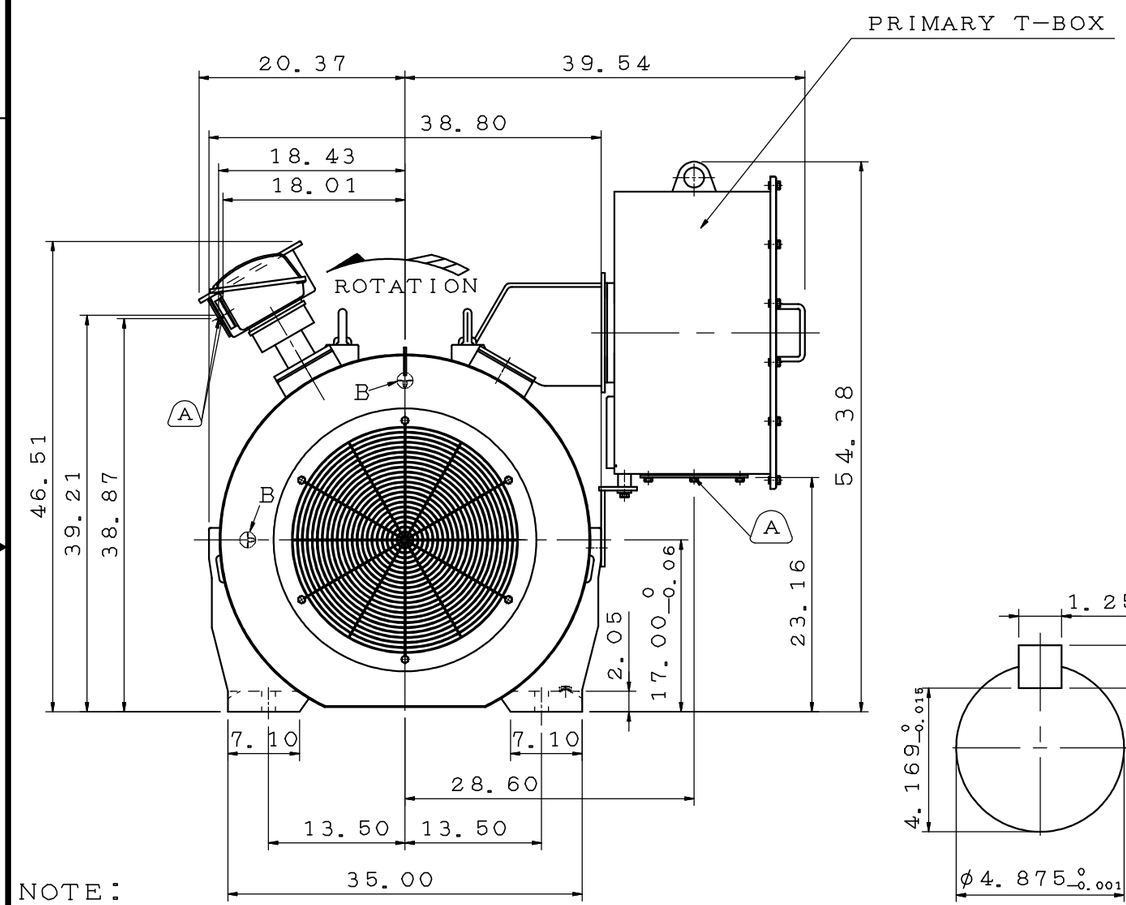
SMITH PUMP COMPANY

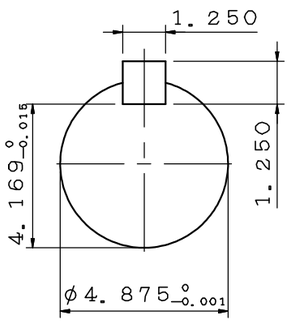
PRODUCT	500 HP Motor & Motor Mount Replacement
PROJECT	SWP MOTOR REPLACEMENT 4160V
OWNER	CITY OF AUSTIN - WALNUT CREEK WWTP
CONTRACTOR	MATOUS CONSTRUCTION
ENG.	HARUTUNIAN ENGINEERING INC.
QTY. FIVE (5)	PROJECT: 161559-04
DWG. NO.	T\CAD\END SUCTION\161559 500HP

DATE	SCALE	BY	CK	REV
2-1-11	1:28	JMJ	LSW	A

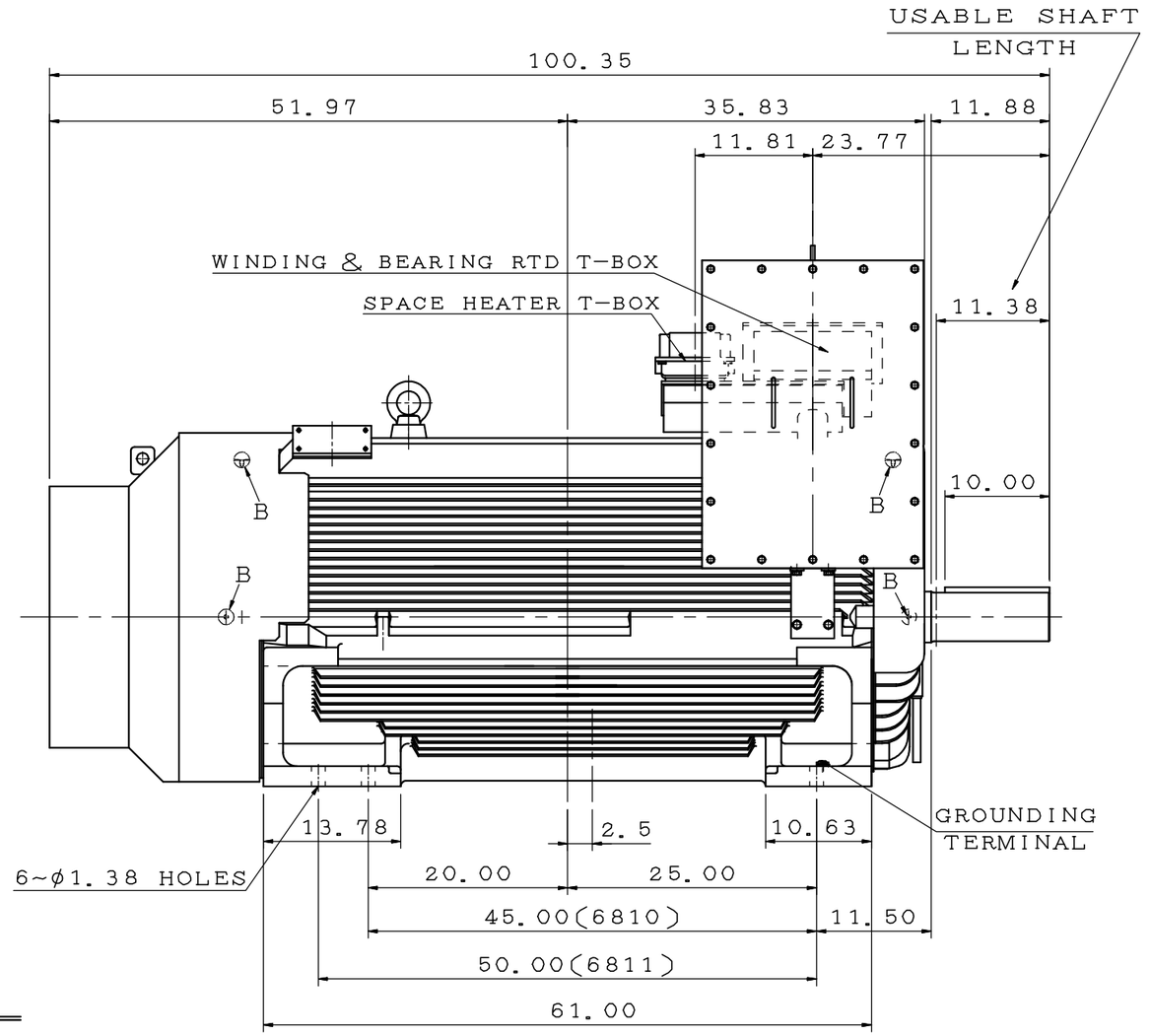
TYPE	OUTPUT		POLE	TIME RATING	VOLTAGE V	Hz	SYN. SPEED R. P. M
	HP.	kW.					
AEHG—TK	500		14	CONT.	4160	60	514

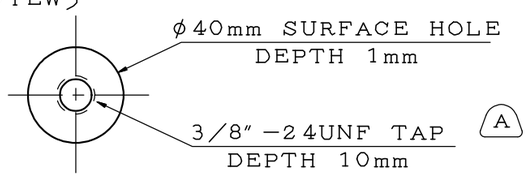
TOTALLY ENCLOSED FAN—COOLED TYPE. SQUIRREL—CAGE ROTOR





SHAFT END
(ENLARGED VIEW)





DETAIL B
PROVISION FOR VIBERATION SENSOR

Ⓐ REMOVABLE COVER FOR MAIN LEAD ENTRY TO BE DRILLED BY CUSTOMER.

NOTE:
1. DIMENSIONS IN INCH
2. FRAME NO. 6810B
3. F CLASS INSULATION, S.F.1.15
4. FOR DIRECT FLEXIBLE COUPLING
5. ENCLOSURE: IP54
6. BEARING SIZE: DRIVE END 6326
   OPP. DRIVE END 6322
7. WITH SPACE HEATER: 1ϕ 120V 300W.
8. WITH WINDING RTD: PT 100Ω/0°C 6PCS
9. WITH BEARING RTD: PT 100Ω/0°C 2PCS
10. TROPIC PROOF
11. NOISE: BELOW 85dBA AT 3 FEET DISTANCE NO LOAD
12. POWER FACTOR CAN BE CORRECTED TO 95.0% WITH THE ADDITION OF 270KVAR CORRECTION CAPACTIORS (RECOMMENDED)
13. APPROX WEIGHT: 11000LBS

DWN.	A. CHEN	JUL•24•2009
CHKD.	H. HUANG	JUL•24•2009
APPD.	C. WANG	JUL•24•2009

DATE

OUTLINE DIMENSIONS
3—PHASE INDUCTION MOTOR

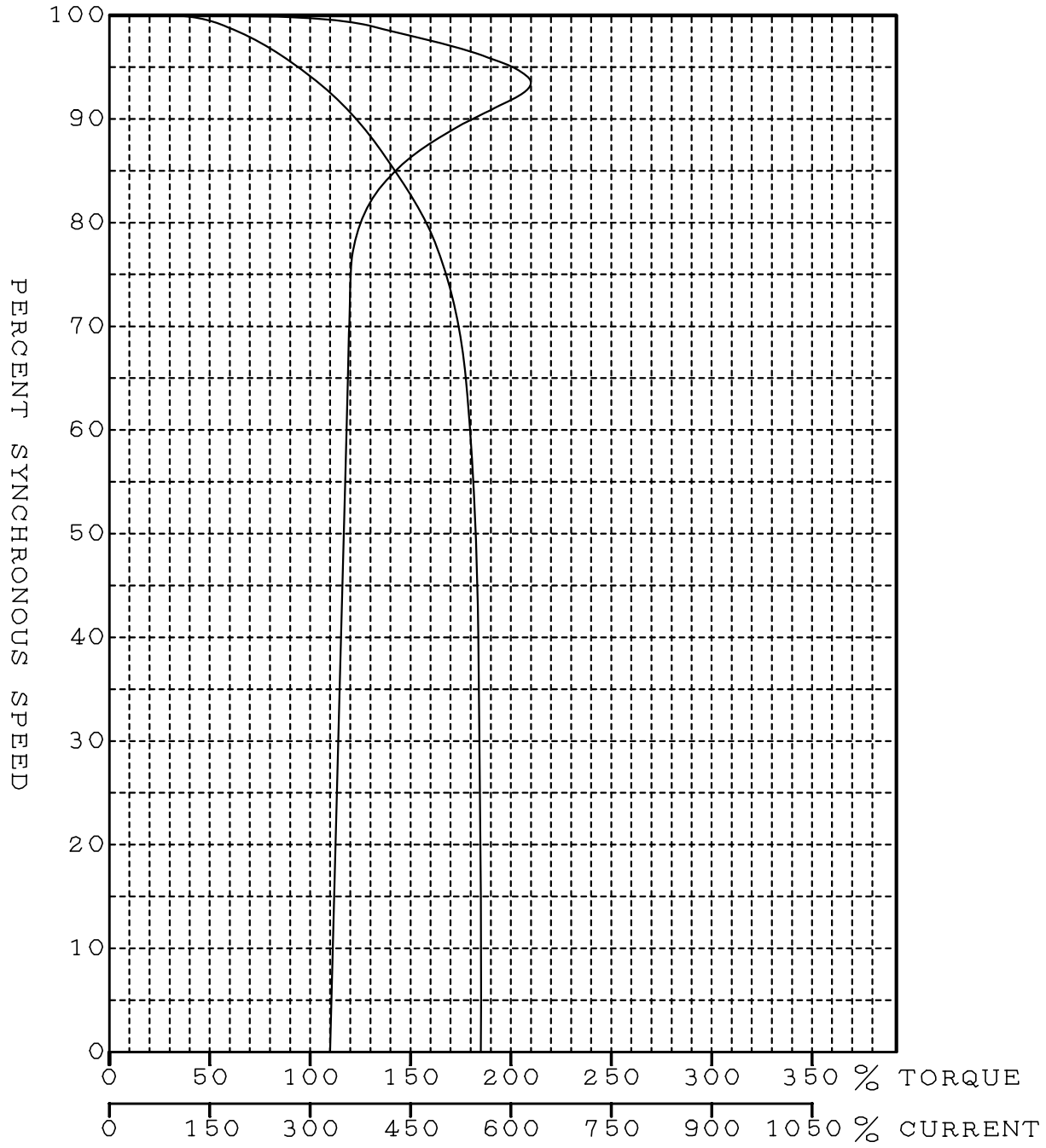
TECO Westinghouse

DWG NO. 3B040W356 REV: 00
11

INDUCTION MOTOR STARTING CHARACTERISTICS

T—N/I—N CURVE

TYPE:AEHG HP:500 VOLTS:4160 ORDER NO:FD13C021T1
HZ:60 POLES:14 RPM(FLS):507
LOCK AMPS(%):555 LOCK TORQUE(%):110



DWG.	NOEL	20131113
APPD.	T.HSIAO	20131113

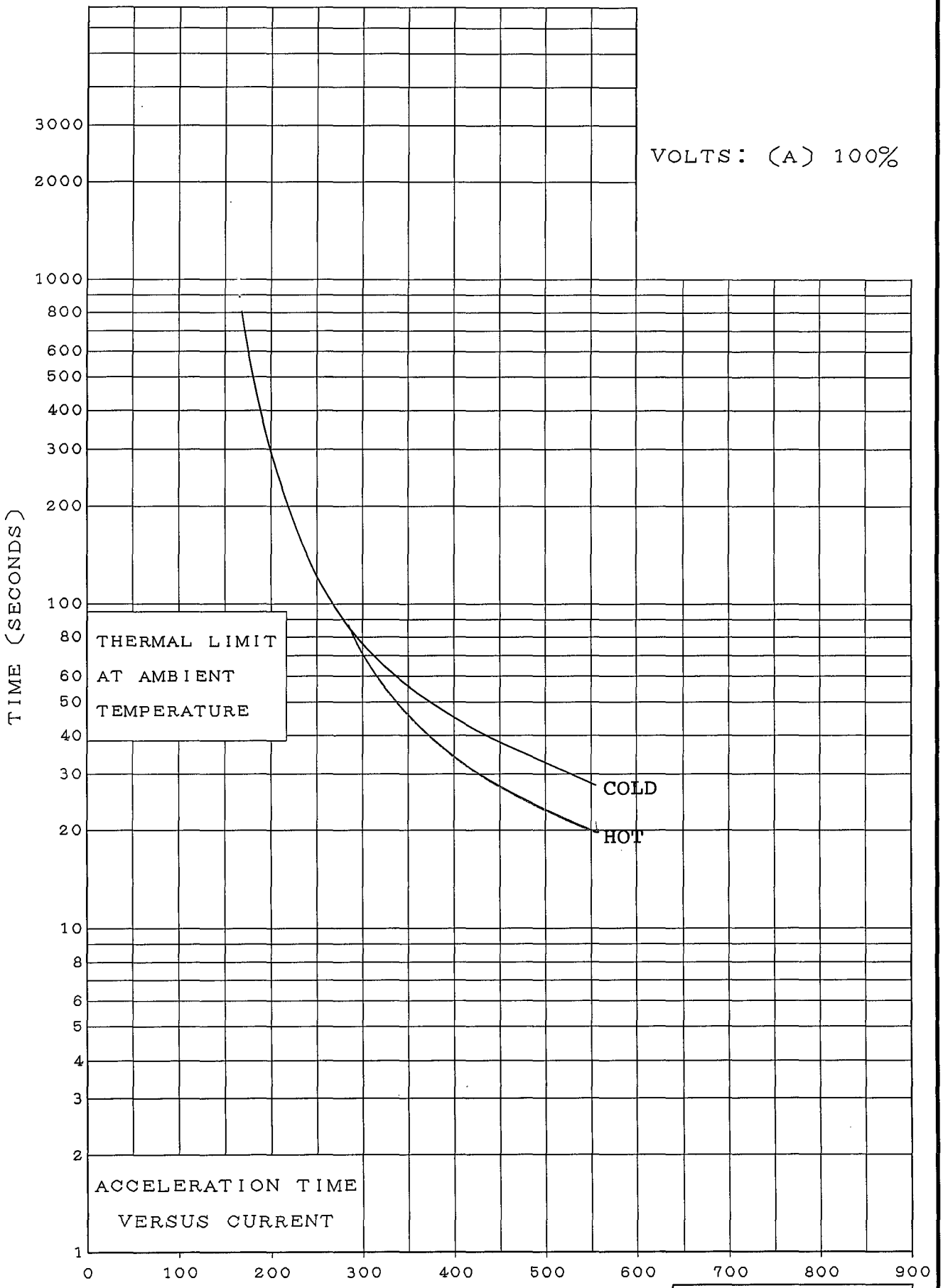
TECO Westinghouse

DWG NO. REV:00
FD13C021T1
T—I—N

Input Ver:00

TIME — CURRENT AND THERMAL LIMIT CURVES

TYPE:AEHG POLE:14 HP:500 NO. :FD13C021T1



DWG.	NOEL	20131113
APPD.	T. HSIAO	20131113

TECO Westinghouse

DWG NO. REV:00
FD13C021T1
TIME

Input Ver:01

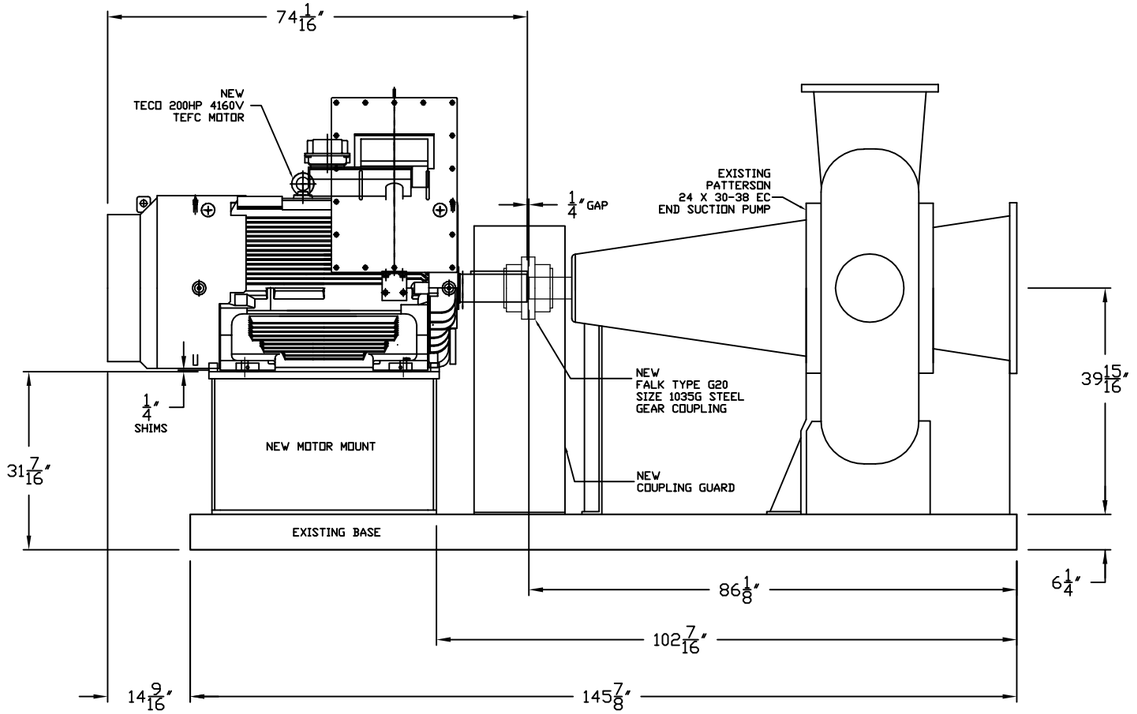
200 HP MOTOR DATA

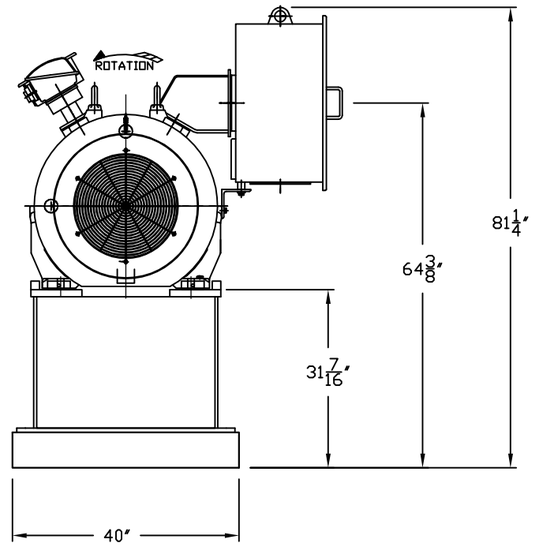
AUG.05.2009

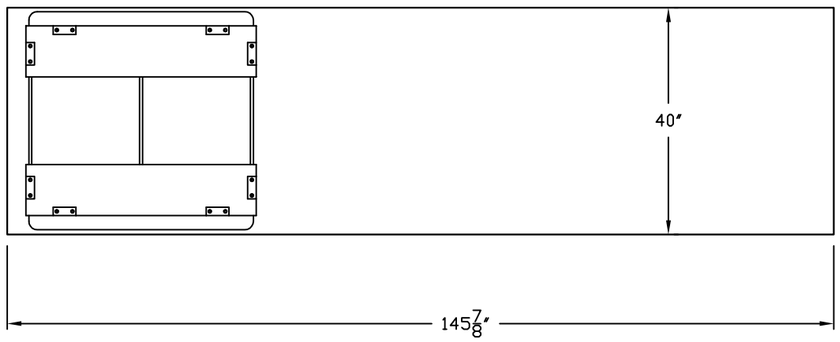
SPECIFICATION TABLE OF 3-PHASE SQUIRREL CAGE INDUCTION MOTOR	CUSTOMER	TWMC	USER	CB01685-I
	INQ. NO.	CB01685	EQUIPMENT	
	JOB NO.	FC09B602T1	MACHINE	
	TOTAL SETS	3	ITEM NO.	

Item	Terms	Description			
1	Model	AEHG-TK			
2	Code or Standard	Dimensions	Frame Assignment	Performance	Test
		NEMA	TWMI	NEMA	NEMA
3	Rating	200 HP 12 Pole 4160 Volt 3 Phase 60 Hz			
4	Service Duty	Continuous Rating , S.F. 1.15			
5	Starting Method	D.O.L. or Auto Transformer			
6	Rotation	Facing The Drive End : CW, Available for Bi-Direction			
7	Drive Method	Direct Coupling			
8	Environment	Amb. Temp. : -20 ~ 40 ℃			
		Humidity : Less Than 95 %RH			
		Altitude : Up to 3300 FT			
9	Enclosure & Protection	IP54 : Totally Enclosure Indoor			
10	Cooling	IC411 : Self External Fan, Surface Cooling			
11	Mounting	IM1001 : HS, Foot			
12	Dimensions	Dr# 3B040W355(REV.00) Frame No ： 5808B			
13	Frame & Bracket	Frame : Cast Iron Bracket : Cast Iron			
14	Fan & Fan Cover	Fan :Aluminum Fan Cover :Steel Plate			
15	Terminal Box	Steel Plate			
16	Lead Terminals	(TLK35-10)X3			
17	Lubrication	ESSO Polyrex EM Grease			
18	Painting	Color : MUNSELL 7.5B 3.5/0.5			
19	Stator Winding	Ins. Class F			
20	Rotor Conductor	Cu-Alloy			
21	Starting Performance	LRC ≦ 175 Amp LRT/FLT 110 %			
22	Operating Performance	Hz/V	60/4160		Break Down Torque
		%Load	100	75	50	210 %FLT
		Amp.	30.1	24	19	
		Eff.%	93.0	92.6	91.6	Temp. Rise Limit. (Res.)
		P.F.%	74.0	70.0	59.5	Stator 80 ℃
		R.P.M.	588	591	594	at S.F.1.0
23	Note	1.With Space Heater : 1φ 120V 200W 2.With Winding RTD : PT 100Ω/0℃ 6pcs 3.With Bearing RTD : PT 100Ω/0℃ 2pcs 4.Noise : Below 85dBA at 3 Feet Distance No Load 5.Approx Weight :5830 Lbs 6.Power Factor Can be Corrected to 95.0% With The Addition of 93KVAR Correction Capacitors (Recommended)			

APPD.	Ming	AUG. 05 2009	TECO Westinghouse	DWG NO. 3A057H186-37528
CHKD.	Sandy	AUG. 05 2009		REV.01
DWN.	Kenny.Shyu	JUL. 13 2009		23 1/1







NOTES:
1. EXISTING MOTOR MOUNTS, MOTORS, & COUPLINGS TO BE REMOVED BY CONTRACTOR
2. NEW MOTOR MOUNTS & MOTORS TO BE ALIGNED AT JOBSITE WITH NEW COUPLINGS, SHIM MOTOR AS REQUIRED.
3. MOTOR BOLT HOLES TO BE DRILLED IN NEW MOTOR MOUNT PADS
4. NEW MOTOR MOUNT TO BE WELDED TO EXISTING BASE AFTER ALIGNMENT
5. NEW MOTOR MOUNT TO BE FILLED WITH NON-SHRINK GROUT AT JOBSITE AFTER ALIGNMENT.
6. ALL BOLTS TO BE 18-8 STAINLESS STEEL.

REV	DATE	DESCRIPTION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES

DECIMALS		ANGLES	
.X	+/-.1	NO DEC.	+/-2DEG
.XX	+/-.06	.X	+/-1.0 DEG
.XXX	+/-.030	.XX	+/-0.5 DEG
.XXXX	+/-.0015	.XXX	+/-0.250 DEG

250

FINISH ALL MACHINED SURFACES
BREAK ALL CORNERS AND SHARP EDGES .010/.030
RADIUS ALL FILLETS .015/.040 R
CHAMFER ALL THREADED HOLES 90/120 DEG
TO A DEPTH OF ONE THREAD +/- .030
SCREW THREAD STANDARDS PER FED-STD-H2B

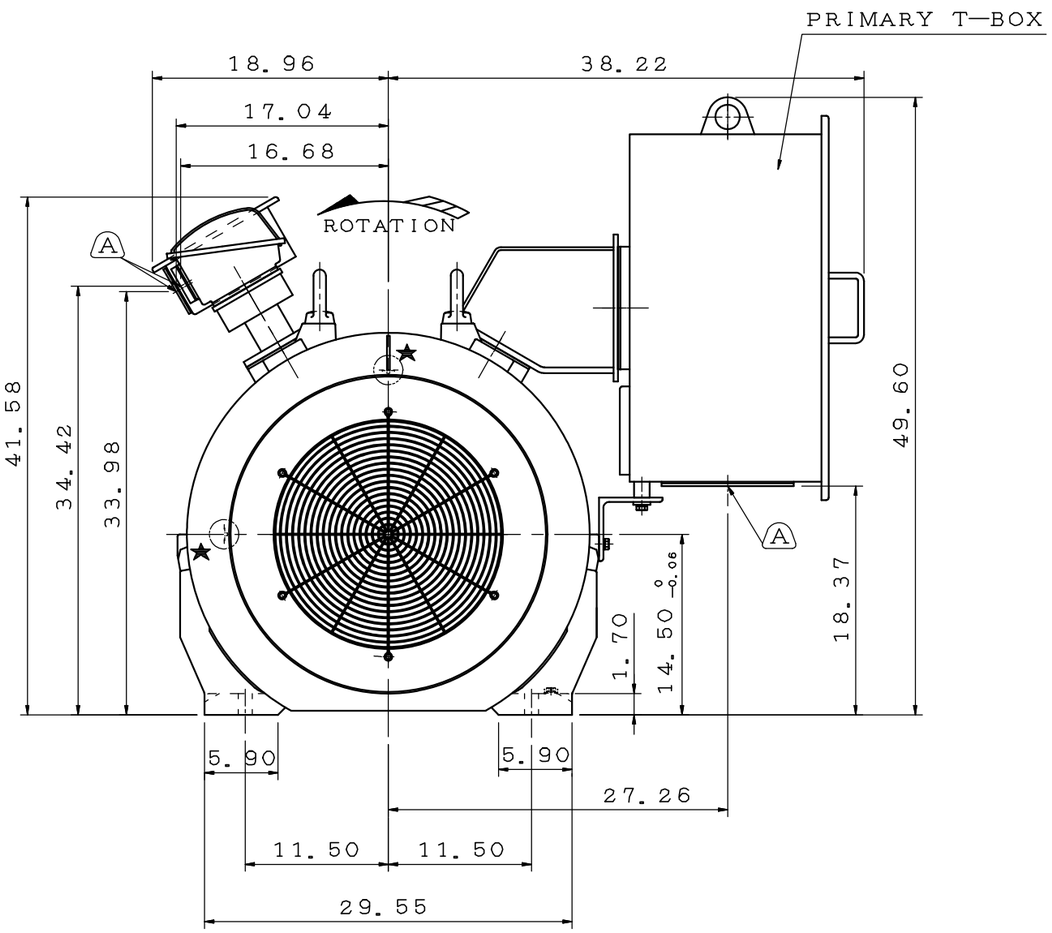
SMITH PUMP COMPANY

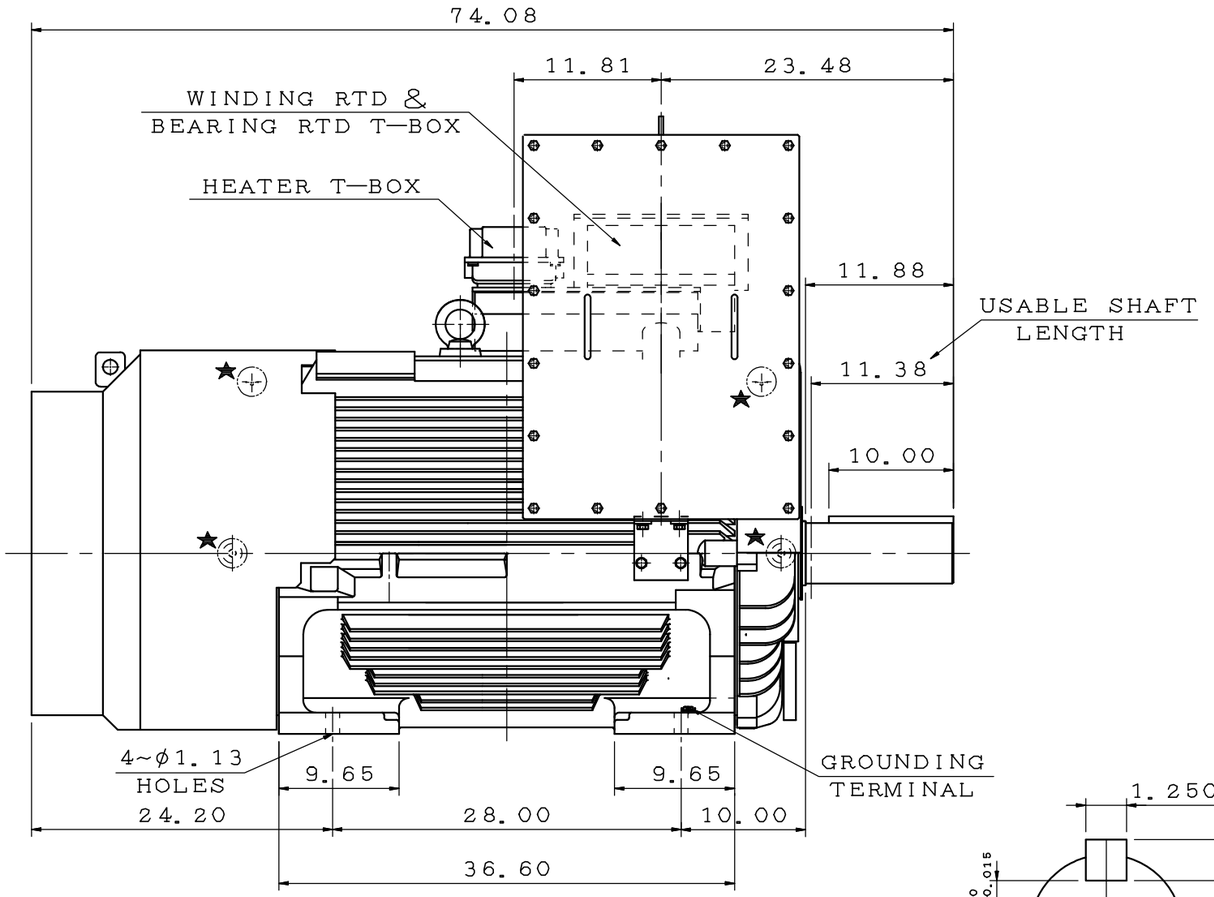
PRODUCT	200 HP Motor & Motor Mount Replacement
PROJECT	SWP MOTOR REPLACEMENT 4160V
OWNER	CITY OF AUSTIN - WALNUT CREEK WWTP
CONTRACTOR	MATOUS CONSTRUCTION
ENG.	HARUTUNIAN ENGINEERING INC.
QTY.	THREE (3) PROJECT: 161559-05
DWG. NO.	T\CAD\END SUCTION\161559 200HP

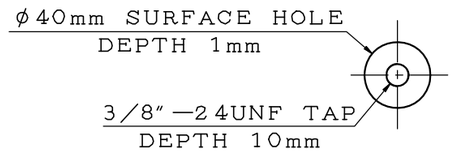
DATE	SCALE	BY	CK	REV
2-1-11	1:27	JMJ	CRT	-

TYPE	OUTPUT		POLE	TIME RATING	VOLTAGE V	Hz	SYN. SPEED R. P. M
	HP.	kW.					
AEHG—TK	200		12	CONT.	4160	60	600

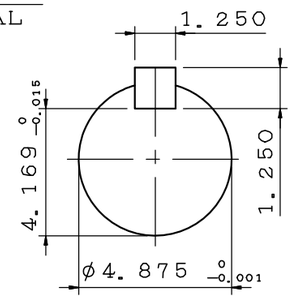
TOTALLY ENCLOSED FAN—COOLED TYPE. SQUIRREL—CAGE ROTOR







DETAIL "★"
(PROVISION FOR VIBRATION SENSOR)



SHAFT END
(ENLARGED VIEW)

NOTE:
1. DIMENSIONS IN INCH
2. FRAME NO. 5808B
3. F CLASS INSULATION, S.F. 1.15
4. FOR DIRECT FLEXIBLE COUPLING
5. ENCLOSURE: IP54
6. BEARING SIZE: DRIVE—END 6326
   OPP. DRIVE—END 6322
7. WITH SPACE HEATER: 1φ 120V 200W
8. WITH WINDING RTD: PT 100Ω/0°C 6PCS
9. WITH BEARING RTD: PT 100Ω/0°C 2PCS
10. NOISE: BELOW 85dBA AT 3 FEET DISTANCE NO LOAD
11. APPROX. WEIGHT: 5830 LBS

Ⓐ REMOVABLE COVER FOR AUXILIARY LEAD ENTRY TO BE DRILLED BY THE CUSTOMER.

DWN.	J. LIU	JUL•20•2009
CHKD.	H. HUANG	JUL•30•2009
APPD.	C. WANG	JUL•30•2009

DATE

OUTLINE DIMENSIONS

3—PHASE INDUCTION MOTOR

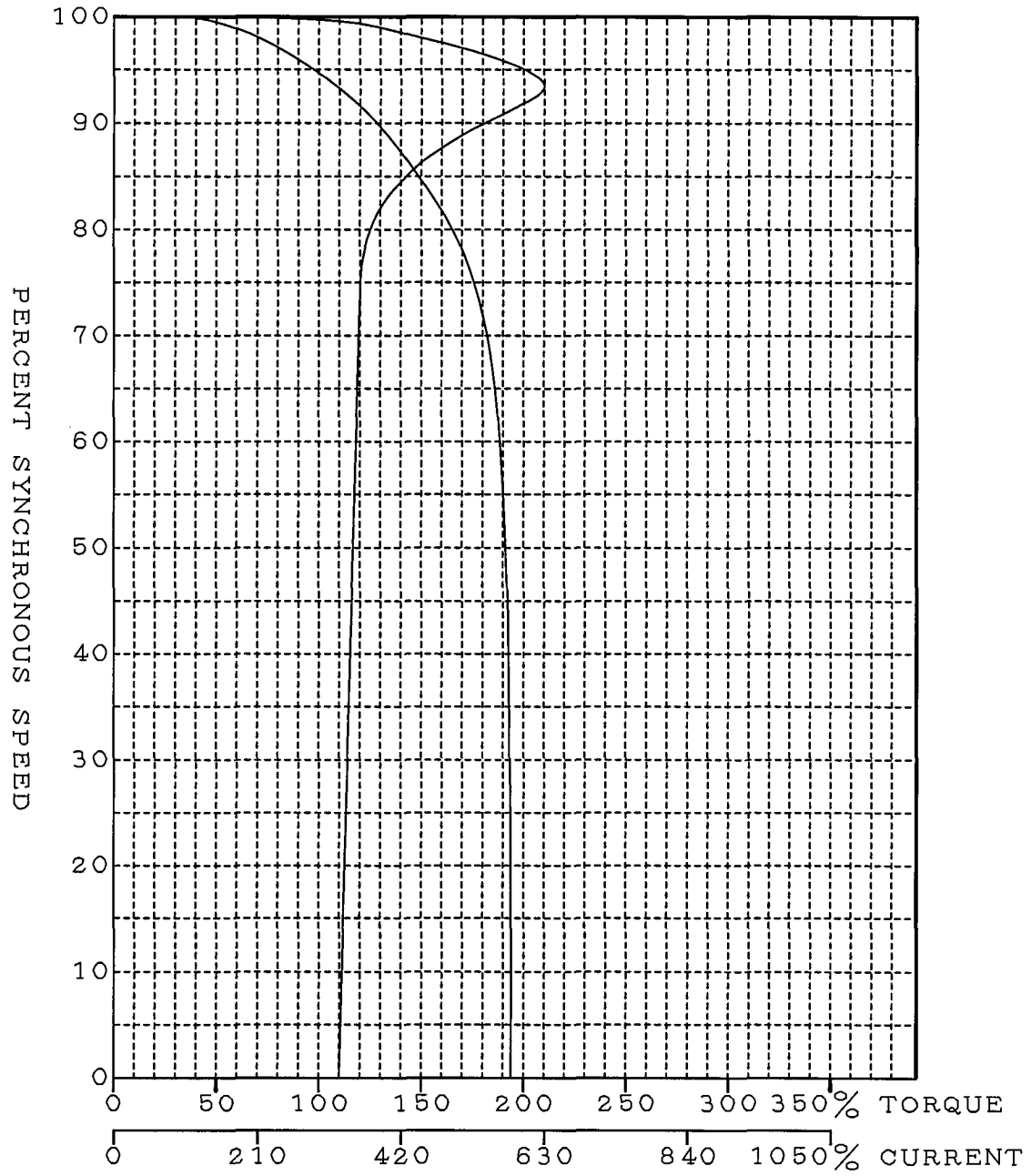
TECO Westinghouse

DWG NO. 3B040W355 REV: 00

INDUCTION MOTOR STARTING CHARACTERISTICS

I—N/T—N CURVE

ORDER NO: FC09B602T1 TYPE:AEHG
HP:200 VOLTS:4160 HZ:60 POLES:12 RPM(FLS):588
LOCK AMPS(%):582 LOCK TORQUE(%):110

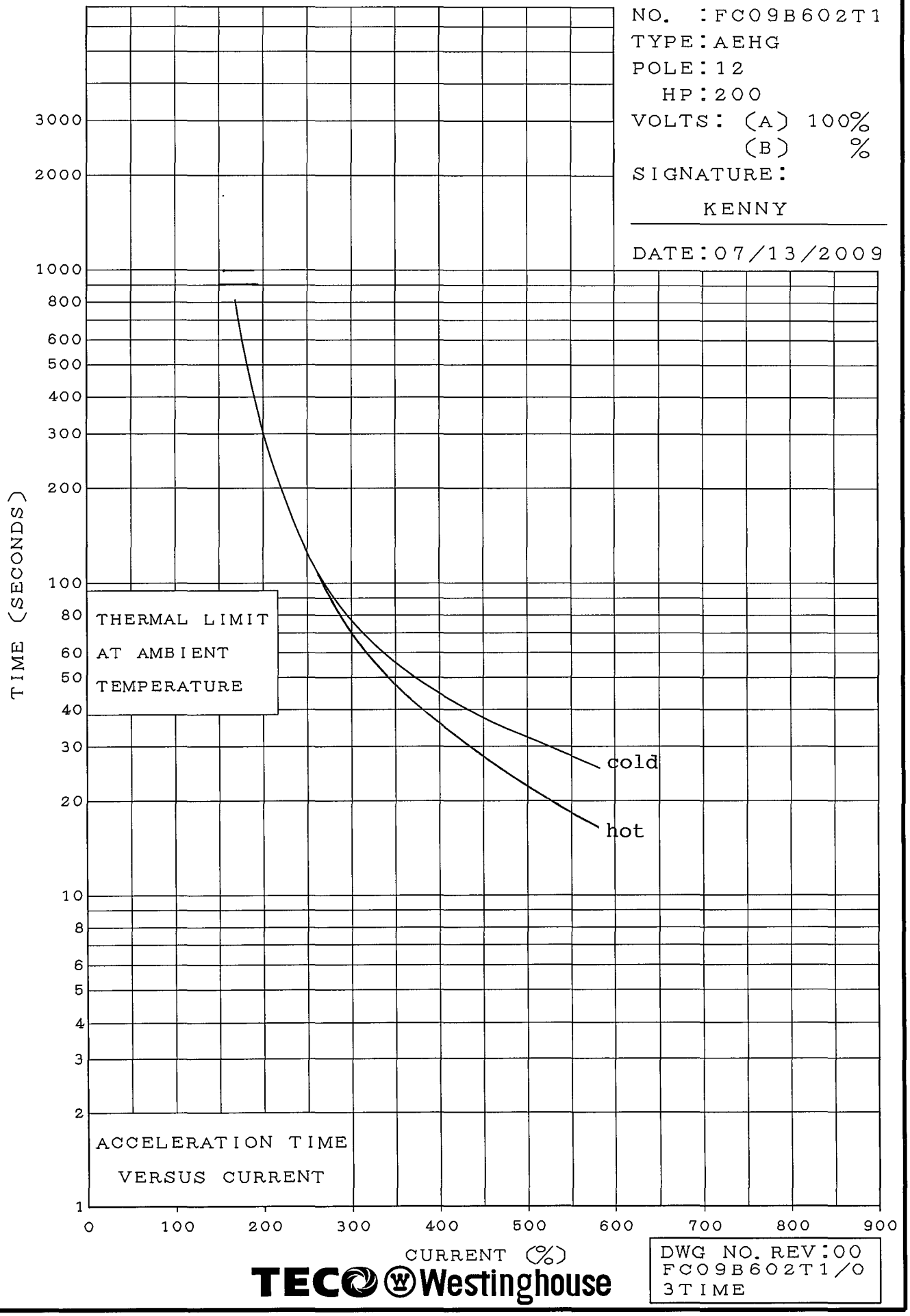


TECO Westinghouse

CURVE NO.
FC09B602T1/0
2I—T

SIGNATURE:KENNY DATE:07/13/2009

TIME — CURRENT AND THERMAL LIMIT CURVES



END OF SECTION

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SECTION 11313

PROGRESSING CAVITY PUMPS AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Provide and test progressing cavity pumps, motors, drives, and appurtenances as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

A. American National Standards Institute (ANSI):

1. B16.5: Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

2. S1.11: Standard Octave-Band and Fractional-Octave-Band and Digital Filters.

B. ASTM International (ASTM):

1. A36: Standard Specification for Carbon Structural Steel.

2. A48: Standard Specification for Gray Iron Castings.

C. Hydraulic Institute: Current Standards.

D. National Electrical Manufacturers Association (NEMA):

1. MG1: Motors and Generators.

1.03 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01300 “Submittals” and Specification Section 01730 “Operation and Maintenance Data” :

1. Data regarding pump and motor characteristics and performance:

a. Prior to fabrication and testing, provide guaranteed performance curves based on actual shop tests of mechanically duplicate pumps, showing they meet indicated and specified requirements for head, capacity and horsepower.

(1) For units of same size and type, provide curves for a single unit only.

b. Provide catalog performance curves at maximum pump speed indicated and specified for each service showing maximum and minimum speeds available, manufacturer’s recommended maximum speed for the operating conditions and service specified and indicated.

c. Results of shop performance tests as specified.

d. Submit curves for guaranteed performance, and shop performance tests on 8-1/2-inch by 11-inch sheets, one curve per sheet.

2. Shop drawing data for accessory items.

3. Certified setting plans, with tolerances, for anchor bolts.

4. Materials listing.

5. Manufacturer's literature as needed to supplement certified data.

6. Operating and maintenance instructions and parts lists.

7. Listing of reference installations as specified with contact names and telephone numbers.

8. Certified results of hydrostatic testing.

9. Bearing temperature operating range for the service conditions specified.

10. List of recommended spare parts other than those specified.

11. Shop and field inspection reports.

12. Bearing Life: Certified by the pump manufacturer. Include design data.

13. Pump shop test results.

14. Motor shop test results.

15. Qualifications of field service engineer.

16. Recommendations for short and long-term storage.

17. Shop and field testing procedures, pump and piping set up, equipment to be used and testing tolerances to be followed.

18. Special tools.

19. Number of service person-days provided and per diem field service rate.

20. Results of field vibration test data including a vibration signature for each pump and drive assembly. Provide vibration testing procedure for review.

21. Recommended location of suction and discharge pressure gauges.

22. Manufacturer’s product data, specifications and color charts for shop painting.

23. Provide a listing of the materials recommended for each service specified and indicated. Provide documentation showing compatibility with process fluid and service specified and indicated.

24. The latest ISO 9001 series certification.

25. Material Certification:

    a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based

on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.

b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.

1.04 SPARE PARTS:

A. Comply with the requirements specified in Section 01600.

B. Provide spare parts that are identical to and interchangeable with similar parts installed.

1. For each pump:

a. One complete set of gaskets and O-rings.

b. One mechanical seal repair kits or replacement mechanical seals.

c. One shaft sleeve.

2. For each set of pumps of the same size and performance.

a. Two sets of rotors and stators.

b. Two pin joint assemblies

c. Two sets of all special tools required.

1.05 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01400.

B. Pumps shall be the product of one manufacturer.

C. Pumps shall be manufacturer's standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.

D. Welding: In accordance with latest applicable American Welding Society Code or equivalent.

E. Shop tests as specified.

F. The Contractor shall obtain the pumps, motors, and appurtenances from the pump manufacturer, as a complete and integrated package to insure proper coordination and compatibility and operation of the system.

G. Services of Manufacturer's Representative as stated in Section 01400 and as specified herein.

H. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:

1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.

2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of piping, electrical and miscellaneous utility connection:

    a. 2 person-days.

3. Functional Testing: Calibrate, check alignment and perform a functional test with water. Tests to include all items specified.

    a. 3 person-days.

4. Performance Testing: Field performance test equipment specified.

    a. 5 person-days.

5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.

    a. 2 person-days.

6. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

I. Manufacturer of pumps shall have a minimum of five (5) operating installations with pumps of the size specified and in the same service as specified operating for not less than five (5) years.

J. If equipment proposed is heavier, larger or taller, different rotation, or discharge arrangement than specified and indicated; provide all structural, architectural, mechanical, electrical and plumbing revisions at no additional cost to the Owner.

1.06 DELIVERY, STORAGE AND HANDLING:

A. Manufacturer shall carefully prepare the units for shipment to minimize the likelihood of damage during shipment. Equipment shall be properly supported and securely attached to skids. Openings shall be covered in a manner to protect both the opening and the interior.

B. Deliver, unload, and store products on site in a manner that prevents damage. Use special care to prevent damage from temperature and condensation.

C. Store in a manner to protect from the elements and physical damage. Include the use of heat lamps, protective film, and provide temporary power for motor heaters.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

A. Pump capacities and operating data are indicated in the Process Pump Schedule.

B. Sludge Pumps: Pump primary sludge with solids concentrations of 0.5 percent to 3.0 percent. Primary sludge system follows primary settling.

C. Scum Pumps: Pump scum from primary settling basins with solid concentrations of 0.5 percent to 4.0 percent.

D. Equipment Limitations:

1. Pumps: Sludge Pumps

a. Maximum Total Pump Assembly Weight: 2,500 lbs.

b. Maximum Pump Assembly Height: 30 in.

c. Maximum Pump Assembly Length x Width: 120 in. x 17 in.

2. Pumps: Scum Pumps

a. Maximum Total Pump Assembly Weight: 1,500 lbs.

b. Maximum Pump Assembly Height: 30 in.

c. Maximum Pump Assembly Length x Width: 120 in. x 17 in.

E. Pumps normally operate with a flooded suction.

2.02 MANUFACTURERS:

A. Progressing Cavity Pumps:

1. Moyno

2. Netzsch

3. Seepex

2.03 PUMP CONSTRUCTION:

A. General:

1. Type: Progressing cavity, self-priming, helical rotary pumps based on Moineau Principle.

2. Provide each pump with number of stages as specified and indicated employing a convoluted rotor operating in a similarly convoluted stator.

3. Provide the convolutions configured to form a cavity between the rotor and stator, progressing from the pump's inlet to discharge port with the operation of the rotor.

4. Provide the fit between the rotor and stator at the point of contact to compress the stator material sufficiently to form a seal and to prevent leakage from the discharge back to the inlet end of the pumping chamber.

5. Provide the stator shall be molded with a seal integral to the stator elastomer preventing the metal stator tube and the bonding agent from the elastomer from contacting the pumped liquid.

a. Gaskets or "O" rings to form this seal are not acceptable

6. The rotor and stator of the pump shall be manufactured such that it can be easily removed from the pump and repaired in place without removing the pump, motor from the frame or any piping that is attached to the pump.

7. Provide pumps driven as indicated in the Process Pump Schedule.

8. Pump Arrangement:

   a. Horizontal.

   b. Capable of forward and reverse rotation.

9. Connections:

   a. Flanged suction and discharge connections faced and drilled to 125 lb. ANSI B16.5, raised face.

   b. Sludge and Scum Services: ASTM A48 Class 30 Cast Iron.

10. Bearings:

   a. Grease lubricated anti-friction type.

   b. Outboard bearing to be combination thrust and radial type; inboard bearing radial type.

   c. Provide bearings in a dust and moisture proof enclosures.

   d. Provide means in bearing housing, such as removable plug diametrically opposite grease fitting, to prevent over greasing of bearing.

   e. Provide bearings with minimum B-10 life rating of 100,000 hours at specified operating conditions and 40,000 hours minimum at 25 percent of the BEP at highest speed, based on latest ABMA and ANSI Standards.

11. Provide pumps driven through a positively sealed and lubricated pin joint.

   a. Provide the pin constructed of high speed steel, air hardened to 60-65 HRc.

   b. Provide the joint grease lubricated with a high temperature (230 degrees C), PTFE filled synthetic grease

   c. Provide the assembly covered with a Buna N sleeve and positively sealed with Type 316 stainless steel hose clamps.

   d. Provide a stainless steel shell covering the rotor side universal joint assembly to protect the elastomer sleeve.

   e. Joint Warranty: 10,000 operating hours, unconditional in regards to damage or wear.

B. Sludge and Scum Pumps:

1. Stator:

    a. Buna-N, 70 to 76 Durometer Hardness.

    b. Outer Casing: Carbon Steel.

    c. Fit stator assembly into pump body containing stuffing box and bearings.

    d. Split stator is not acceptable.

2. Rotor:

    a. Alloy steel with a chromium nitride coating with a hardness of 1250 Vickers and a minimum thickness of 0.0108 inches.

    b. Ceramic coatings are not acceptable due to the ease at which this coating will crack and the lack of diffusion into the rotor base metal.

3. Pump Body:

    a. ASTM A48 Class 30 Cast Iron.

    b. Provide handhole cleanouts 180 degrees apart.

    c. Provide suction port capable of 360 degree rotation in 90 degree increments.

4. Shaft:

    a. AISI 420 stainless steel.

    b. Provide replaceable Type 316 stainless steel or hardened tool steel shaft sleeves.

    c. Pumps without shaft sleeves are unacceptable.

5. Seals: Provide type of seals as indicated and specified.

C. Seals:

1. Single Acting Mechanical Seals:

    a. EagleBurgmann MG1-Q1Q1VGG or equal

        (1) Seal Faces: Silicon carbide

        (2) Elastomers: Viton

        (3) Metal Parts: Type 316 stainless steel

2. Use of flush water is not required.

2.04 RUN DRY PROTECTION:

A. Provide run dry protection fitted into the stator.

B. Provide a controller to monitor the stator temperature and activate a shutdown and alarm sequence if the stator temperature reaches the adjustable limit on the controller. Controller shall be DIN rail mountable.

1. Manufacturer to provide temperature settings

C. Provide the controller with a manual local and remote reset function.

D. 115VAC/60 Hertz.

2.05 OVER PRESSURE PROTECTION:

A. Provide pressure indicating transmitters as shown on PLANs.

2.06 MOTORS:

A. Provide in accordance with Section 15172 and as specified and indicated.

B. Horsepower rating of motors: Not less than maximum brake horsepower requirements of pumps under any condition of operation specified and indicated without operating in the motor service factor.

C. Motor enclosure and motor speed: As indicated in the Process Pump Schedule.

D. Provide motors for horizontal pumps with mounts for bolting to baseplate.

E. In addition to the requirements for bearings specified under Electric Motors in Section 15172, provide pump motors with ball or roller bearings. Provide bearing with a minimum B-10 life of 100,000 hours.

F. Overall sound-pressure level of each motor shall not exceed 88 decibels when measured on flat network using an octave-band frequency analyzer conforming to ANSI S1.11. Determine overall sound-pressure level as average of four or more readings at evenly spaced points, 3 feet from motor.

G. Operate without overheating at the speeds specified and indicated.

H. Service Factor: 1.15

I. Premium efficiency with nominal and minimum efficiencies per NEMA MG1.

J. Rating: 460V, 3 PH, 60 Hertz.

K. Insulation: Class F with Class B temperature rise, 40 degree C ambient.

L. Site Altitude: 460 above sea level.

M. Provide Inpro/Seal bearing isolators.

2.07 BASEPLATES:

A. Horizontal Pumps:

1. Mount each pump and drive on a common base.

a. Material: ASTM A36 fabricated structural steel.

b. Provide structural steel shape bases, bent form bases are not acceptable.

c. Provide bases with provisions for grouting and for anchor bolts.

d. Design baseplates to support pump and driver.

e. Provide planed surfaces of bearing pads for pumps and drives.

2.08 DRAIN AND VENT PIPING:

A. Provide drains from stuffing box and casing vent and drain piping and valves to discharge into gutters or sumps as indicated and as directed by the **Engineer**.

B. Drain and vent piping: Schedule 5 Type 316L stainless steel with Pressfit connections or Schedule 40 Type 316L stainless steel with socket welded connections. Provide a sufficient number of unions to permit removal of each valve and in-line device.

C. Provide pipe and fittings in accordance with Section 15225 and as indicated.

D. Valves: Provide size and type as indicated and in accordance with Section 15100.

2.09 GAUGES:

A. Provide pressure sensors and gauge assemblies for suction and discharge of each pump.

B. Suction Gauges: compound type with operating range at approximately mid-point of the gauge range.

1. Scale: psi

C. Discharge gauges: Provide standard range with top limit above pump shutoff head at maximum pump speed.

1. Scale: psi

2.10 SHOP PAINTING:

A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces, high solids epoxy in accordance with Section 09902.

B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.

C. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

2.11 SHOP TESTING:

A. Provide motor shop testing in accordance with Section 15172.

B. Pump Tests:

1. Test pump casings under a hydrostatic head of 150 percent of rated pressure. Test wet end with pump assembled.

2. Provide certified performance tests as specified herein for all pumps.

3. Certified performance testing.

   a. Run pump at full speed rating point for 60 minutes prior to start of any testing.

   b. Full speed tests:

      (1) Test pumps at the conditions specified and indicated and take not less than seven operating points between shut-off and run out. Test points must be at the conditions specified and indicated.

      (2) Take readings to determine flow, differential pressure, rpm, horsepower, displacement and efficiency.

      (3) Operate each pump for not less than one hour and take readings to determine that the pump will operate as specified and indicated without cavitation at the specified minimum head condition with not more than the specified NPSH available. Test with the job submergence as indicated.

   c. Factory tests on pumps:

      (1) Use tested job motors.

   d. Provide a minimum of 30 days written notice to the **Engineer** prior to shop testing.

4. Run all tests in accordance with the latest standards of the Hydraulic Institute and as specified.

5. Testing Tolerances: ANSI/HI

6. Repeat tests until specified results are obtained.

7. Correct or replace promptly all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install items in accordance with accepted shop drawings, manufacturer's printed instructions and as indicated.

B. Install pumping units on a concrete pad and align thereon.

1. Set base on metal shims placed directly under the part of the base carrying the greatest weight and spaced close enough to provide uniform support.

C. After alignment is correct, grout using high grade non-shrink grout.

1. Fill entire base and leave no gaps or voids.

2. Do not imbed leveling nuts in grout.

3.02 FIELD TESTING:

A. Test piping connections to prove the pump nozzle are installed with the pipe in a free supported state and without need to apply vertical or horizontal pressure to align piping with pump nozzles. This must be performed and the piping acceptable prior to any field performance testing.

B. Field testing will not be conducted without an accepted procedure, calibration certificates for all testing equipment, gauges and flow meters and a completed and signed pretesting check list. See Division 1 for checklist.

C. After installation of pumping equipment, and after inspection, operation, testing and adjustment have been completed by the manufacturer's field service technician, conduct running test for each pump in presence of the **Engineer** to determine its ability to operate within the vibration and temperature limits specified, and to deliver its rated capacity under specified conditions.

1. During tests, observe and record head, capacity, pump bearing housings and motor bearing temperature, noise and motor inputs.

a. Bearing Temperature: Bearing temperature not to exceed 180 degrees F.

b. Test Duration: Determined by the **Engineer**, but not less than three hours of continuous operation at each condition specified and indicated.

2. Run each pump for minimum two hours prior to taking temperature readings of the pumps, motors, and gears.

3. Immediately correct or replace all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.

4. Repeat tests until specified results are obtained.

5. Contractor to provide all labor, piping, testing equipment, equipment, flow meters and test gauges for conducting tests. Contractor may use plant-wide non-potable water for pump testing, as applicable.

a. Contractor shall provide calibrated test gauges for all permanently installed gauges and portable calibrated flow meters for all pumping systems even in those cases where permanent flow meters are installed.

b. All instruments, meters and other measurement devices used during the tests shall be calibrated within 90 days of the tests. Copies of the certificates of calibration shall be submitted to the Owner's representative prior to witnessing the tests.

c. The testing will not be started and will not be accepted until the calibrated testing equipment stated above is operational and all certifications have been submitted.

d. Contractor is responsible for delivery and disposal of water used for testing.

D. Make all adjustments necessary to place equipment in specified working order at time of above tests.

E. Test pump on product only. If product is not available, test with water. Water for testing furnished by Contractor.

F. Remove all replaced equipment at no additional cost to the Owner with equipment that will meet all requirements specified and indicated if unable to demonstrate to the satisfaction of the **Engineer** that equipment will perform the service specified, indicated and as submitted and accepted.

3.03 FIELD TOUCH-UP PAINTING:

A. After installation and accepted testing by the **Engineer**, apply touch-up paint to all scratched, abraided and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.04 – 3. 10 NOT USED

3.11 MEASUREMENT AND PAYMENT

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.

ATTACHMENT "A"

PROCESS PUMP SCHEDULE

Parameter	Pump Requirements	
Pump Identification	Scum	Sludge
Number of Unit(s):	3	5
Pumping Unit(s) Designation:	FEC1-SCP-001 FEC1-SCP-002 FEC2-SCP-001	FEC1-SLP-001 FEC1-SLP-002 FEC2-SLP-001 FEC2-SLP-002 FEC2-SLP-003
Type of Service	Scum	Primary Sludge
Pumping Unit Drivers:	Electric Motor	Electric Motor
Location	PTC1 and PTC2	PTC1 and PTC2
Water Temperature	35°F-85°F	35°F-85°F
Suction Size (inch)	8	8
Discharge Size (inch)	6	6
Pumping Capacity (gpm)	150	220
Differential Pressure at Rated Capacity (PSI)	120	120
Maximum Number of Pump Stages	2	2
Pump Full Speed (RPM) not to exceed	275	275
Hydrostatic Pressure Test (PSI)	120	120
Horsepower Rating (HP)	25	40
Pump Speed	Constant	Constant
Service Factor	1.15	1.15
Maximum Drive Nominal Speed (RPM)	1800	1800
Voltage	460 Volts, 3-phase, 60 Hz	460 VAC, 3-phase, 60 Hz
Enclosure	TEFC	TEFC
Shaft	Solid	Solid

END OF SECTION

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SECTION 11325

BASE-MOUNTED CENTRIFUGAL HYDRONIC PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Frame mounted, centrifugal, horizontal end suction, long coupled pumps with drivers and features as scheduled.

1.02 RELATED REQUIREMENTS

A. PLANS show general arrangement, location and basic dimensions. Attachment “A” to this Specification Section gives performance and design requirements.

B. Related work as called for on PLANS or specified in this or other TECHNICAL SPECIFICATIONS Sections.

1.03 REFERENCES

A. The publications listed below form a part of the Specification to the extent referenced. The publications are referred to in the text by basic destination only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 48	Standard Specification for Gray Iron Castings
ASTM A 276	Standard Specification for Stainless and Heat Resisting Steel Bars and Shapes
ASTM A 283	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM B 62	Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 584	Standard Specification for Copper Alloy Sand Castings for General Applications.

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	Centrifugal Pumps for Nomenclature and Definitions
HI 1.3	Centrifugal Pumps for Design and Application
HI 1.6	Centrifugal Pump Tests
HI 9.1-9.5	Pumps - General Guidelines for Types, Definitions, Application, and Sound Measurement and Decontamination

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI C 1045 Carbon Steel

1.04 DEFINITIONS

A. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 1.1-1.2, 1.3, 1.6, and 9.1-9.5 and as modified in this Section.

B. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

C. Tolerances: In accordance with HI 1.1-1.2, 1.3, 1.6, and 9.1-9.5, unless specified more restrictively.

1.05 SYSTEM DESCRIPTION

A. Horizontal, centrifugal, end suction pump. The Contractor shall furnish materials, equipment and labor to furnish, install and test the pumping system complete with the pumps, motors, mounting bases, piping, valves and appurtenances, as indicated on the contract drawings and as herein specified.

B. Design requirements:
   1. Pump performance characteristics: As specified in the Pump Schedule.
   2. Motor characteristics: As specified in the Pump Schedule.

1.06 SUBMITTALS

A. Submit the following in accordance with Specification Sections 01300 “Submittals” and Specification Section 01730 “Operation and Maintenance Data”.

B. Shop Drawings
   1. Pump design data including name of pumping unit Manufacturer, pump model number, rotating speed, proposed impeller size, maximum and minimum impeller size to fit proposed pump case, type of wear rings and materials for impeller and case wear rings, type of pump bearings (radial and axial), type of mechanical seal and materials of construction, net weight of pump and net weight of base plate.
   2. Factory-certified pump performance curve showing capacity in gpm versus total dynamic head (TDH), NPSH required, brake horsepower required, operating speed, and wire-to-water efficiency. Curve to be complete from shut-off to minimum TDH.
   3. Complete outline drawing of the pump and motor showing overall dimensions, installation details, location of terminal boxes, mounting provisions, and lifting provisions. Sectional drawing showing all components and a list of materials for each component per ANSI, ASTM, NEMA. Show motor shaft diameter at all points.
   4. Information covering availability of parts and service.

C. Operation and Maintenance Manuals

D. Certified Report: Furnish a report prepared by manufacturer’s technical representative certifying satisfactory installation, operation, and in service placement of units.

1.07 QUALITY ASSURANCE

A. System Coordination: Contractor is responsible for all details necessary to properly install, adjust, and place in operation a working system.

B. Standardization: All pumps to be product of a single manufacturer.

C. Motor compatibility: The manufacturer shall ensure that the motor included with the pump is compatible with the pump equipment and complies with these specifications.

D. Manufacturer qualifications:
   1. Experience: Demonstrate minimum 10 years experience in manufacture of horizontal end suction, long coupled pumps which have been successfully utilized for heating, chilled water and dual temperature water system.
   2. Pump manufacturer shall be ISO 9000 certified.
   3. References: Provide a reference list of at least 5 different installations in the continental United States, where the manufacturer has supplied equipment substantially similar in design and characteristics to that proposed here. The installations listed must:
      a. Have been designed and fabricated by the manufacturer.
      b. Be at least equal to the horsepower to that of the largest unit specified.
      c. Have been in continuous operation for last 5 years.
      d. Include in the list the name, address, and telephone number of the OWNER, horsepower, and the time in operation.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver, unload, and store products on site in manner that prevents damage. Use special care to prevent damage from temperature and condensation.

B. Flanges to be protected by wooden blank flange protectors, strongly built and securely bolted thereto, or otherwise attached.

C. Power and control cables to be shipped with securely attached caps on cable ends to prevent moisture wicking into cable while stored.

1.09 – 1.10 (NOT USED)

1.11 MAINTENANCE

A. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

B. Spare parts: Deliver the following in accordance with CONTRACT Requirements.
   1. Pump thrust bearing set.
   2. Pump radial bearing set.
   3. Gasket set.
   4. Motor bearing set of each type.
   5. Pump impeller, trimmed to match installed impeller.
   6. Mechanical seal rebuild set.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Pump: One of the following or equal:
   1. Xylem Bell & Gossett E-1510 series.
   2. or approve equal

2.02 MATERIALS AND/OR EQUIPMENT

A. The pumps shall be long coupled, base mounted, single stage, end suction, vertical split case design, in cast iron stainless steel fitted, specifically designed for quiet operation. Suitable standard operations at 225°F and 175 PSIG working pressure or optional operations at up to 250°F and 250 PSIG working pressures. Working pressures shall not be de-rated at temperatures up to 250F. The pump internals shall be capable of being services without disturbing piping connections, electrical motor connections or pump to motor alignment.

B. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupling.

C. A bearing assembly shall support the shaft via two heavy-duty regreaseable ball bearings. Bearing assembly shall be replaceable without disturbing the system piping and shall have foot support at the coupling end. Pump bearings shall be regreaseable without removal of the bearings from the bearing assembly. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.

D. The bearing assembly shall have a solid SAE1144 steel shaft. A stainless steel shaft sleeve shall be employed to completely cover the wetted area under the seal.

E. Pump shall be equipped with an internally-flushed mechanical seal assembly installed in an enlarged tapered seal chamber. Application of an internally flushed mechanical seal shall be adequate for seal flushing without requiring external flushing lines. Seal assembly shall have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

F. Bearing assembly shaft shall connect to a stainless steel impeller. Impeller shall be both hydraulically and dynamically balanced to ANSI/HI 9.6.4-2009, balance grade G6.3 and secured by a stainless steel locking cap screw or nut.

G. Pump should be designed to allow for true back pull-out allowing access to the pump's working components, without disturbing motor or piping, for ease of maintenance.

H. A center drop-out type coupling, capable of absorbing torsional vibration, shall be employed between the pump and motor. Pumps for variable speed application shall be provided with a suitable coupling sleeve. Coupling shall allow for removal of pump's wetted end without disturbing pump volute or movement of the pump's motor and electrical connections. On variable speed applications the coupling sleeve should be constructed of an neoprene material to maximize performance life.

I. An ANSI and OSHA rated coupling guard shall shield the coupling during operation. Coupling guard shall be dual rated ANSI B15.1 and OSHA 1910.219 compliant coupling guard and contain viewing windows for inspection of the coupling. No more than .25 inches of either rotating assembly shall be visible beyond the coupling guard.

J. Pump volute shall be of a cast iron design for heating systems with integrally cast pedestal volute support, rated for 175 PSIG with integral cast iron flanges drilled for 125# ANSI companion flanges. (As scheduled herein and as specified in Section 15172.) Volute shall include gauge ports at nozzles, and vent and drain ports.

K. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8.2.1-2009 for grouted Horizontal Baseplate Design standards.

L. Pump shall be of a maintainable design and, for ease of maintenance, should use machine fit parts and not press fit components.

M. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 9.6.4-2009 for recommended acceptable unfiltered field vibration limits (as measured per ANSI/HI 9.6.4-2009 Figure 9.6.4.2.3.1) for pumps with rolling contact bearings.

N. Each pump shall be hydrostatically tested 1.5 times the maximum rated working pressure and name-plated before shipment.

O. Pump shall conform to ANSI/HI 9.6.3.1-2012 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.

P. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be factory aligned, and shall be realigned after installation by the manufacturer's representative. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications and conform to standards outlined in EISA 2007.

2.03 FABRICATION (NOT USED)

2.04 SOURCE QUALITY CONTROL

A. Prepare surfaces and apply protective finishes as specified in Section 09902.

B. Factory Test: Each pump is to be tested at the factory to determine capacity, shut-off head, rated head, minimum head (for continuous operation), required power and efficiency as required to develop an accurate performance curve. Certified copies of a report for each test are to be submitted to the Owner. All of the above tests are to be performed in conformity with the requirements and recommendations of the Hydraulic Institute.

C. Hydrostatic pressure tests: As specified for components in this Section.

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment specified in this Section and associated accessories as per manufacturer's printed instructions, shop drawings, and recommendations. .

3.02 FIELD TESTING

A. Test piping connections to prove the pump nozzle are installed with the pipe in a free supported state and without need to apply vertical or horizontal pressure to align piping with pump nozzles. This must be performed and the piping acceptable prior to any field performance testing.

B. Field testing will not be conducted without an accepted procedure, calibration certificates for all testing equipment, gauges and flow meters.

C. Manufacturer's Field Services: Furnish services of manufacturer's trained, competent, technical representative to provide a minimum of two eight-hour working day assistance for the proper installation, operation, and maintenance of the equipment to perform the following:

1. Inspect the completed installation for conformance with manufacturer's recommended installation requirements;
2. Supervise operational test of each unit;

3. Instruct OWNER's personnel in operation and maintenance of equipment; and
4. Prepare and certify field inspection report.

D. Inspection: Manufacturer's technical service representative to perform, at a minimum, the following for each unit:
1. Check proper rotation;
2. Check power supply voltage;
3. Measure motor no-load current; and

E. Placing in Service
1. Before Start-Up:
   a. Check impeller and make sure all rotating elements are free and clear.
   b. Check direction of motor rotation with pump disconnected to ensure the direction of pump and motor are compatible.
   c. Have manufacturer's representative inspect and approve installation.
2. Complete unit, when assembled and operating, to be free from excessive vibration, cavitation, and noise.
3. CONTRACTOR to perform a functional test to verify the installed equipment operates at the rated design conditions. Functionally test each unit for a minimum of two (2) hours after all components reach Normal Operating temperature. During the test, observe and record head, capacity, vibration, and noise. Promptly correct or replace all defects or defective equipment at no additional cost to OWNER, and repeat tests until the specified results are obtained.
   a. Provide vibration signature test data for each pump and drive assembly.
      1) Limit: 50 percent of ANSI/HI allowable limits.
   b. Bearing Temperature: Bearing temperature not to exceed 180 degrees F (82 degrees C).
4. CONTRACTOR shall provide labor, material, equipment, piping, and calibrated measuring equipment for conduction the tests. All calibrations must be within 30 days of the field testing.

3.03 FIELD TOUCH-UP PAINTING

A. After installation and testing accepted by the Engineer, apply touch-up paint to all scratched, abraided and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.04 – 3.10 (NOT USED)

3.11 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.

ATTACHMENT A – PERFORMANCE REQUIREMENTS

Tag Numbers	OP-CWP-001 OP-CWP-002 OP-CWP-003
Pump designation	Cooling Water Pumps
Service	Potable Water
Quantity	3
Maximum Noise, dBA at 3 feet	85
Minimum Pumped Fluid degrees F.	50
Normal Pumped Fluid degrees F.	70
Maximum Pumped Fluid degrees F.	110
Primary Design Point, Flow, Gallons per Minute	210
Primary Design Point, Head, Feet	115
Primary Design Point, Minimum Efficiency, Percent	72
Secondary Design Point, Flow, Gallons per Minute	280
Secondary Design Point, Head, Feet	90
Secondary Design Point, Minimum Efficiency, Percent	68
Shut-off Head to be higher than, Feet	140
Run-out Point Pump Head to be less than, Feet	60
Allowable Operating Range, Gallons per Minute	90-340
Preferred Operating Range, Gallons per Minute	150-280
Maximum NPSHa at Every Specified Flow, Feet	20
Driver Type	Electric Motor
Drive Arrangement	Horizontal, Coupled
Maximum Driver Horsepower	10
Maximum Driver Speed, Revolutions per Minute	3600
Motor Specification Section	15172
Service Factor	1.15
Voltage/Phases/Hertz	460/3/60
NEMA Enclosure Type	TEFC

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SECTION 11330

IN-LINE MACERATORS AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Provide and test in-line macerators, controls and appurtenances as indicated and specified.

1.02 REFERENCES:

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

1. A395: Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

2. A536: Specification for Ductile Iron Castings.

B. American National Standards Institute (ANSI):

1. S1.11: Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets.

C. National Electrical Manufacturers Association (NEMA):

1. MG1: Motors and Generators.

D. Underwriters' Laboratories, Inc. (UL):

1. 508: Industrial Control Equipment

1.03 SUBMITTALS:

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 "Operation and Maintenance Data":

1. Certified shop and erection drawings. Contractor shall submit electronic files of the proposed equipment in the capacity, size and arrangement as indicated and specified.

2. Data regarding macerator, gear reducer and motor characteristics and performance:

a. Prior to fabrication and testing, provide guaranteed performance curves based on actual shop or field tests of mechanically duplicate equipment, showing they meet indicated and specified requirements for capacity, pressure drop and horsepower.

(1) For units of same size and type, provide curves for a single unit only.

b. Results of shop performance tests as specified.

c. Submit curves for guaranteed performance, and shop performance tests on 8-1/2-inch by 11-inch sheets, one curve per sheet.

3. Shop drawing data for accessory items.

4. Certified setting plans, with tolerances, for anchor bolts.

5. Manufacturer's literature as needed to supplement certified data.

6. Listing of reference installations as specified with contact names and telephone numbers.

7. Certified results of hydrostatic testing.

8. Bearing temperature operating range for the service conditions specified.

9. List of recommended spare parts other than those specified.

10. Shop and field inspection reports.

11. Bearing Life: Certified by the macerator manufacturer. Include design data.

12. Macerator shop test results.

13. Motor shop test results.

14. Additional information as required in Specification 13390, “Packaged Control Systems”.

15. Qualifications of field service engineer.

16. Recommendations for short and long-term storage.

17. Shop testing procedures and equipment to be used including the details of all equipment and testing set up.

18. Field testing procedures and equipment to be used including the details and calibration certificated of all equipment and portable flow meter locations.

19. Special tools.

20. Number of service person-days provided and per diem field service rate.

21. Schematic control and power wiring diagrams.

22. Manufacturer’s product data and specifications for painting.

23. Provide a listing of the materials recommended for each service specified and indicated. Provide documentation showing compatibility with process fluid and service specified and indicated.

24. The latest ISO 9001 series certification.

25. Provide a scaled drawings showing the equipment and motors including equipment weights, lifting attachments, slings and clearance for equipment removal and maintenance.

26. Material Certification:

    a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based

on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.

b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.

B. A copy of the contract mechanical process, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with “No changes required” or provide a statement that no changes are required.

1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.

1.04 SPARE PARTS:

A. Comply with the requirements specified in Section 01600.

B. Provide spare parts that are identical to and interchangeable with similar parts installed.

1. For each macerator:

a. One complete set of gaskets.

b. One set of cutters.

c. One set of spacers.

2. For each set of macerators of the same size and performance.

a. One set of all special tools required.

b. Provide one spare rotating assembly with motor.

3. Reference specification section 13390 for additional spare parts.

1.05 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01400.

B. Equipment specified shall be the product of one manufacturer.

C. Equipment shall be manufacturer’s standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.

D. Welding: In accordance with latest applicable American Welding Society Code or equivalent.

E. Shop tests as specified.

F. The Contractor shall obtain the macerators, motors, gear reducers and controls, from a single macerator manufacturer, as a complete and integrated package to insure proper coordination and compatibility and operation of the system.

G. Services of Manufacturer's Representative as stated in Section 01400 and as specified herein.

H. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:

1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.

2. Installation: Inspect location of anchor bolts; pump setting, leveling, alignment, field erection; coordination of piping, electrical and miscellaneous utility connections:

   a. 2 person-days.

3. Functional Testing: Calibrate, check alignment and perform a functional test with water. Tests to include all items specified.

   a. 2 person-days.

4. Performance Testing: Field performance test equipment specified.

   a. 2 person-days.

5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.

   a. 2 person-days.

6. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.

7. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

I. Manufacturer of macerators shall have a minimum of five (5) operating installations with equipment of the size specified and in the same service as specified operating for not less than five (5) years.

J. If equipment proposed is heavier or taller, different rotation, or discharge arrangement than specified and indicated; provide all structural, architectural and mechanical revisions at no additional cost to the Owner.

1.06 DELIVERY, STORAGE AND HANDLING:

A. Manufacturer shall carefully prepare the units for shipment to minimize the likelihood of damage during shipment. Cavities shall be drained of water. Equipment shall be properly supported and securely attached to skids. Openings shall be covered in a manner to protect both the opening and the interior.

B. Deliver, unload, and store products on site in a manner that prevents damage. Use special care to prevent damage from temperature and condensation.

C. Store in a manner to protect from the elements and physical damage. Include the use of heat lamps, protective film, and provide temporary power for motor heaters.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

A. Macerator capacities and operating data are indicated in the Macerator Schedule herein.

B. Sludge and Scum: Macerators will be on sludge pump suction, pumping sludge from primary clarifiers to a sludge processing facility. In bypass configuration, scum is pumped through macerators and sludge pumps combination. Solids concentration is up to 6 percent.

2.02 MANUFACTURERS:

A. Netzsch

B. Vogelsang RotaCut

C. or, approved equal.

2.03 MACERATOR CONSTRUCTION:

A. capacities and operating data are indicated in the Macerator Schedule in Attachment A.

B. Body:

1. The macerator body shall consist of a drum with flanged piping connections, flanged cleanout (6-inch minimum) and hinged top cover plate. The cover plate shall be reinforced to bear the weight to the drive and cutter assembly and shall be held in place by one or more quick-opening latches. The top opening shall be sealed with an O-ring seal to sustain an internal pressure of not more than 30 psig. Piping connections shall be 125 psi ANSI B16.1 and shall be located at 180 degrees (in plan) from each other and shall be concentric with each other. The flanges shall be located in the upper half of the drum to permit storage for periodic removal of heavier objects in the flow processed by the machine. A mounting frame shall be provided to permit anchor bolting the macerator to the housekeeping pad indicated. Installation details shall conform to the requirements.

2. The top cover hinge mechanism shall be reinforced and of sufficient strength to, when the cover has been opened, to hold the drive unit, cover plate and cutter assembly firmly in a position which places the cutter shaft in essentially a horizontal position with the cutter assembly exposed for maintenance. The hinge assembly shall also provide sufficient strength to allow removal and reassembly of the drive and cutter assembly. The top cover hinge hatch shall be locked into place with a simple hand latch for easy access. A hydraulic mechanism shall provide both assist and shock dampening action during the opening/closing process. A NEMA safety switch shall be provided with contacts set to open when the cover latch is not in the engaged position.

3. Internally, the macerator shall be configured to induce a rotational effect in the flow processed by the machine to encourage centrifugal separation of heavy objects such as stones and metal items.

C. Seals:

1. Provide labyrinth type device and end face mechanical seals.

2. Face materials: Tungsten carbide to tungsten carbide not requiring any external flushing or any type of lubrication.

3. Products requiring lubrication or flushing are not acceptable.

4. Mechanical seal rating: 29 psi continuous duty by seal manufacturer.

5. Housing: Replaceable cartridge that supports and aligns bearings and seals. Housing to provide protection of the shafts and end housings.

6. Provide integrity of seal independent of stack tightness.

   a. O-rings: Buna-N.

D. Cutting Assembly:

1. The cutting assembly shall consist of a matched cutter (consisting of a star shaped multiple arm mounting of a minimum of 3 cutting blades) and hardened cutter screen selected to provide the specified particle passing size. The cutter shall mount the blades to effect efficient cutting in both the forward and reverse direction. Screens shall be designed to be reversed by maintenance personnel to provide extended life before they must be replaced. Screens that do not support the blades, have continuous bars, or wear on both sides of the screen shall not be accepted.

E. Automatic Cutting Control

1. The cutter shall rotate on the drive shaft and be held in position against the grid / screen by an automatic tensioning device. The automatic tensioning device shall automatically adjust the tension of the cutting blades without manual user intervention, using high pressure air over the top of an oil chamber or through the compression force of a spring.

2. If using hydraulic tensioning, the automatic tensioning controls shall have one air canister and one oil canister with a pressure regulator between them. Each canister shall have their own pressure gauge to verify pressure, and pressure valve to add pressure via a simple hand pump. The automatic tensioning control shall use a hydraulic cylinder to adjust the blades for optimum cutting performance.

3. If using spring tensioning, the adjustment should be made from a single turning nut to apply uniform tension.

4. Macerators without automatic tensioning devices shall not be considered.

F. Driver:

1. The drive unit shall consist of an electric motor, operating through a TWO-STAGE planetary gear to achieve an operating speed of 320 rpm maximum. The concentric shaft, planetary gear shall be designed in accordance with AGMA 6010-E for continuous heavy duty shock loading and shall be sealed in grease.

2. The drive motor shall be of the type specified and shall be energy efficient, conforming to the requirements of the specifications.

3. The mechanical seal on the gear output shaft shall be a non-metallic design using an O-ring seal in a bath of hydraulic fluid to protect the gear motor from entrance of sludge into the gear motor enclosure.

G. Controllers:

1. Provide in accordance with Section 13390 “Packaged Control System”.

2. Provide a programmable logic controller with ladder logic programming.

3. Provide thermal motor overload protection and single phase protection.

4. Furnish all controls for operation of unit, circuit breaker, motor starter, control transformer, pushbuttons and relays.

5. Provide the following control functions:

a. Hand-Off/Reset-Auto switch.

b. Control logic that restricts resetting an overload condition from a remote location.

c. Start/Stop pushbutton.

d. Motor heater coils as an integral part of an adjustable overload relay.

e. Overload relay to detect single phase and phase imbalance with motor full load amps adjustable so that the range selected includes the full load amp rating and service factor.

f. When overload and power failure occur, design system for overload indicators to reactivate when power resumes.

6. Jam Condition:

a. When a jam condition occurs, design controller to stop the macerator and reverse its rotation. If the jam is cleared the controller will return to normal operation.

b. When the auto reverse is activated due to a jam and it reverses and clears the jam and it continues to rotate in the reversed direction for more than ten seconds, the maximum attempt counter will reset to zero.

c. The control system to be designed and programmed to reverse automatically at a user changeable present intervals. The auto reverse function is used to continuously sharpen the blades.

d. If a jam condition is not cleared after the first reversal, design controller to go through four additional reversing cycle, which is tracked in the program via the “maximum attempt counter”. If the counter reaches the maximum count, it will fault the system for a jammed condition, signaling a macerator overload condition.

e. Overload to shut down macerator and activate fail contact, an alarm relay (dry contact).

f. Power Failure:

(1) If while the macerator is running, the macerator shall resume running when power is restored.

(2) If the macerator is stopped due to an overload condition and a power failure occurs, the overload indicator shall reactivate when power is restored.

7. Provide the following indicating lights:

a. Power on

b. Each overload

c. Run (RED)

d. Each maintenance condition.

8. Provide momentary contact stop/Reset and Start pushbuttons.

9. Provide an auxiliary overload relay for remote, overload and/or alarm indication.

10. Enclosure:

a. Material:

(1) NEMA 4X Areas: Type 316 stainless steel

b. Comply with UL 508 Standards.

11. Provide a reversing motor starter, full voltage reversing type.

12. Provide lamp test button.

13. At minimum, provide the following free digital inputs capable of interfacing with the Owner's control system:

a. Remote control device input (operates the macerator in automatic mode from the Owner's PLC)

b. Field control station selector switch "ON" input (starts the macerator)

c. Field control station selector switch "REMOTE" input (enables the macerator to be operated from the vendor controller)

14. At minimum, provide the following free digital outputs capable of interfacing with the Owner's control system:

a. Motor running forward output

b. Motor running in reverse output

c. Macerator common alarm output

H. Instrumentation and Control

1. General

a. Reference Section 13390, “Packaged Control Systems” for general instrumentation and control requirements.

b. Reference the PLANS for general instrumentation and control requirements.

2.04 MOTORS:

A. Provide in accordance with Section 15172 and as specified and indicated.

B. Motor enclosure and motor speed: As indicated in the Macerator Equipment Schedule.

C. In addition to the requirements for bearings specified under Electric Motors in Section 15172, provide equipment motors with ball or roller bearings. Provide vertical motors with at least one bearing designed for thrust with bearings. Provide bearing with a minimum B-10 life of 100,000 hours.

D. Overall sound-pressure level of each motor shall not exceed 88 decibels when measured on flat network using an octave-band frequency analyzer conforming to ANSI S1.11. Determine overall sound-pressure level as average of four or more readings at evenly spaced points, 3 feet from motor.

E. Operate without overheating at the speeds specified and indicated.

F. Service Factor: 1.15.

G. Premium efficiency with nominal and minimum efficiencies per NEMA MG1.

H. Rating: 460V, 3 PH, 60 Hertz.

I. Insulation: Class F with Class B temperature rise, 40 degrees C ambient.

J. Site Altitude: Less than 3,300 feet above sea level.

2.05 SHOP PAINTING:

A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces, high solids epoxy in accordance Section 09902.

B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.

C. Provide additional shop pain coating for touch-up to all surfaces after installation and testing is completed and equipment is accepted.

2.06 SHOP TESTING:

A. Macerator Tests:

1. Test casings under a hydrostatic head of at least 30 psi.

2. Test all functions of each controller.

3. Repeat tests until specified results are obtained.

B. Correct or replace promptly all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install items in accordance with manufacturer's printed instructions, as indicated and specified.

B. Install macerators on a concrete pad and align thereon.

1. Set base on metal shims placed directly under the part of the base carrying the greatest weight and spaced close enough to provide uniform support.

C. After alignment is correct, grout using high grade non-shrink grout.

1. Do not imbed leveling nuts in grout.

3.02 FIELD TESTING:

A. Comply with the requirements as specified herein.

B. Test piping connections to prove the macerator nozzles are installed with the pipe in a free supported state and without need to apply vertical or horizontal pressure to align piping with the macerator nozzles.

C. After installation of macerators, and after inspection, operation, testing and adjustment have been completed by the manufacturer's field service technician, conduct running test for each macerator in presence of the **Engineer** to determine its ability to:

1. Deliver its rated capacity under specified conditions.

2. Operate within the vibration and temperature limits specified.

3. During tests, observe and record pressure drop, flow, motor inputs, bearing housing temperature, noise and vibration.

4. Immediately correct or replace all defects or defective equipment revealed by or noted during tests, at no additional cost to the Owner, and repeat tests until specified results and results acceptable to the **Engineer** are obtained.

5. Contractor to provide all labor, piping, equipment, flowmeters, test gauges and materials for conducting tests.

a. Contractor shall provide calibrated test gauges for all gauges and portable calibrated flow meters for all systems even in those cases where permanent flow meters and gauges are installed.

b. The testing will not be started and will not be accepted until the calibrated testing equipment stated above is operational.

6. Bearing and Motor Temperature:

a. Run each macerator for minimum 30 minutes prior to taking temperature readings of the gears and motors.

b. Bearing temperature not to exceed bearing temperature recommended by the manufacturer.

7. Test Duration: Determined by the **Engineer**, but not less than one hour of continuous operation at each condition specified and indicated.

D. Make all adjustments necessary to place equipment in specified working order at time of above tests.

E. Test on product only.

3.03 FIELD TOUCH-UP PAINTING:

A. After installation and testing acceptable to the **Engineer**. Contractor shall apply touch-up paint to all scratched, abraided and damaged shop painted surfaces. Coating type and color shall match shop painting.

3. 04 – 3. 10 NOT USED

3.11 MEASUREMENT AND PAYMENT

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.

ATTACHEMENT A

MACERATOR SCHEDULE

SERVICE	Scum and/or Sludge from Primary Clarifiers
Tag No.:	PTC1-MRT-001 PTC1-MRT-002 PTC2-MRT-001 PTC2-MRT-002
Location:	Primary Treatment Complexes 1 and 2 (PTC1 and 2)
Solids Concentration:	2 percent to 6 percent
Design Flow, gpm:	220
Pressure Drop, max, inches @ design flow:	12.0
End Connections:	Flanged, 6-inch
Motor hp:	5
Motor Enclosure:	TEFC
Macerator RPM, max:	320

END OF SECTION

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’S 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 – AW Host Pack Spreadsheets” is hereto made part of this section and includes OWNER’S requirements associated with the AW 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 – AW 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. Panels shall be designed, constructed, and tested by a UL508 certified entity.

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. The PCS equipment shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment.
   3. At all times the PCS equipment shall be housed inside a moisture free, non-porous, extra heavy duty plastic weatherproof housing.
   4. Interior and exterior of PCS equipment shall be kept clean at all times.
   5. 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, 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.

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. The input/output point listing shall be submitted along with the product data. Submittals excluding the input/output point listing shall not be accepted. 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.
   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), alarms, data points associated with the protective relays/power monitoring units and telemetered through the Modbus/TCP communication data link connected to the PCS (minimum points as described hereinafter), and additional data points that are available to or can be developed by the PCS as requested by the Owner. 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 the 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 AW 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 – AW Host Pack Spreadsheets for additional requirements for bidding purposes.
4. Minimum data points to be telemetered by the PCS for protective relays/power monitoring units that are connected to the PCS are as follows: Voltage

(average, A-B,B-C,C-A), Current (average, A, B, C, Ground), power factor, horsepower, kw, kvar, kva, mwh, and all alarms and trip conditions that are configured on the protective relay/power monitoring unit.

5. Electronic files of PLC program in editable electronic files and PDF on CD-ROM. Follow the file format as described hereinafter.
6. 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.
7. 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 coil 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 – PLC CPU memory cards, with minimum of five of each type used.
14. Ten percent – Ethernet switches, minimum of one of each type used.
15. Ten percent – OIU, with minimum of one of each type used.
16. One (1) spare PLC rack of each type used.
17. One (1) spare power supply of each type of power supply (24VDC, etc.) 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 and OIU screen 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 and OIU screens 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 – AW 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 an arc-flash study, harmonic study, and a coordination study, complete with short circuit calculations and coordination curves, etc. as required by and in compliance with Section 16120 of the Specifications "480 Volt Motor Control Centers", paragraph 1.08 "Special Manufacturer's Services.
   1. The characteristics of the main PCS protective device that are most suitable for the system in providing proper protection and coordination (i.e., symmetrical short circuit rating, current limiting, electronic trip, etc.) shall be determined per Section 16120 of the Specifications "480 Volt Motor Control Centers", paragraph 1.08 "Special Manufacturer's Services. 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 at No Additional Cost to the OWNER.
   2. The Manufacturer shall select, set, and adjust the load side devices served by the main PCS protective device accordingly at No Additional Cost to the OWNER. 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. 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. Where process taps/connections are located higher than 5 feet above finished floor/grade, furnish and install remote mounted indicating transmitters and extend tubing as required to facilitate mounting transmitters no higher than 5 feet above finished floor/grade.
9. 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 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 and 17600. Group conductors and route in wireways as specified in Section 17200. Wire insulation

pigmentation for 480 VAC circuits shall be per Section 16200. Field wiring 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.
   6. Where junction/pull boxes are required, furnish and install per Section 16250.

H. All outdoor located enclosures and field indicators/transmitters shall also have a sunshield hood per Section 17380 and as detailed on the PLANS, with the following exceptions:
   1. PCS manufacturer to adjust the sunshield dimensions as necessary to coordinate with the dimensions of the control panel/instrument.
   2. The hinged flap detailed on the PLANS is not required for control panels.
   3. Orient as described on the PLANS and coordinated with 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:
   1. Enclosures located outdoors: NEMA Type 4X, Type 316 Stainless Steel enclosures. Enclsoures shall have a smooth, non-brushed finish.
   2. Enclosures located indoors in process/mechanical areas and storage areas that are not environmentally and climate controlled: NEMA Type 4X, Type 316 Stainless Steel enclosures.
   3. Enclosures located indoors in areas that are environmentally and climate controlled: NEMA 12-gasketed, painted steel enclosures per Section 17200.

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 door mounted variable depth disconnect operating mechanism for operating the main circuit breaker and providing access to the 480V compartment. Provide padlockable disconnect operating handle. Handle shall be mechanically interlocked with the door/barrier to prevent personnel from opening the door and accessing the 480V compartment 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 9421 or approved equal. Electric actuated door interlock means will not be accepted.

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 enclosure manufacturer's factory interior backpanels and sidepanels as required to facilitate interior device mounting. Panels shall be factory painted white.

G. For all PCS enclosures containing components rated greater than 120 VAC and components rated 120 VAC and less, the enclosure shall consist of two compartments. Each compartment shall have an independently operating door. A barrier shall extend the full height and depth of the enclosure to separate the two compartments and isolate power and control components rated 120 VAC and less from all components rated greater than 120 VAC.

H. The following are required for all outdoor enclosures containing PLCs and for indoor enclosures containing PLCs that are located in Process/Mechanical areas and Storage areas that are not environmentally and climate controlled:
   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.

g. Manufacturer: EIC Solutions, or approved equal.

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 that 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 a temperature transmitter 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. The internal cabinet ambient air temperature shall be visible exterior of the cabinet, regardless if the temperature value is displayed on any OIU screen. Furnish and install a discrete digital indicator as required to display the internal cabinet ambient air temperature.

I. Furnish and install the following additional accessories for each enclosure:
   1. For each door:
      a. Grounding bonding jumper.
      b. Door stop kit.
      c. 12-inch 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 all additional enclosure accessories, mounting hardware, 19 inch rack accessories, etc., as required for a functional PCS.
   4. Additional requirements for indoor enclosures located in areas that are environmentally and climate controlled: Furnish and install enclosure complete with all accessories per Section 17200.

J. Enclosures shall be as manufactured by:
   1. All outdoor enclosures and indoor enclosures located inside process/mechanical areas and storage areas that are not environmentally and climate controlled:
      a. Wall mounted control panel: Hoffman Concept Stainless Steel 4X Wall Mounted Enclosure Series with CWHPTO Padlock Handle, or approved equal.
      b. Free Standing control panel: Hoffman Free-Standing Single and Dual Access with 3-Point Latches and Lockable Powerglide® Handles, Type 4X Enclosures, or approved equal.
   2. Indoor enclosures located inside environmentally and climate controlled areas: Furnish and install per the requirements of Section 17200.

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 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.
      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.
      e. Furnish and install a sun shield as specified in Section 17380 for all OIUs installed on enclosures located outdoors.
   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. Although not shown on the PLANS, furnish and install one 120Vac, 1P-20A GFI convenience receptacle and 1 Cat 5e Ethernet data port receptacle with NEMA 4X rated hinged UV resistant clear polycarbonate cover. Receptacles shall be accessible from control panel exterior without requiring access to internal control panel components. Wire receptacles to Ethernet switch and control power supply of internal control panel. Furnish and install receptacles as manufactured by Hubbell "Panel-Safe", model PR4X205E or approved equal.

c. 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 control relays and timing 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 MOTOR STARTERS AND VARIABLE FREQUENCY DRIVES

A. Furnish and install per the requirements of Section 16120 Subsection 2.04 “Combination Units” with the following exceptions:
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. Size and configuration (full voltage non-reversing, full voltage reversing, etc.) as required for the application. Size per NEC and provide minimum of NEMA Size 1.
4. Control Power Transformer:
a. Dedicated control power transformer for each motor starter is not required. Serve starter control power from PCS control power distribution per the manufacturer’s standard.
5. Power Factor Correction Capacitors (PFCCs):
a. Furnish and install PFCCs for all constant speed motors sized three horsepower and larger. Exception: Motorized valves and reversing/jogging process applications do not require power factor correction capacitors.
b. Connect capacitors between the motor starter and the overload relay.
6. Variable frequency drive:

a. Drive family (Constant torque, variable torque, etc.) to be selected by the Division 11 equipment manufacturer.
b. The VFD minimum output current shall be as determined by the Division 11 equipment manufacturer.
c. 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. Where 6 pulse VFDs are installed, furnish and install a harmonic filter dedicated to each 6 pulse VFD per Section 16120, at a minimum. Locate the harmonic filter inside of the PCS enclosure.

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

SECTION 13390

APPENDIX A - PACKAGED SYSTEMS PLC PROGRAMMING CRITERIA

PART 4 PACKAGED SYSTEMS PLC PROGRAMMING CRITERIA

4.01 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.

4.02 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.

4.03 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 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 to 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.

4.04 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 (example 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

SECTION 13390

APPENDIX B – AW HOST PACK SPREADSHEETS

PART 5 AW HOST PACK SPREADSHEETS

5.01 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 PLC/RTU 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 Host Pack 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. Information required for each entry.
   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.

5.02 HOST PACK 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 were it is sending its information to.

B. Information required for each entry.
   1. Host SCADA Configuration Information – the fields in this section relate to configuration of alarming and general point information for use in the 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 anoter 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.

5.03 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 Host Pack list.
4. Information required for each entry.
    a. 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.
    b. DESCRIPTION - A description of the signal. The description field is limited to 40 characters.
    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. 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.
    e. 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.
    f. 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.
    g. 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.
    h. 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.
    i. 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.
    j. 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.

k. BLOCK MOVE TYPE – Indicates the function block or other method used to facilitate the transfer of peer data.
l. 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.
m. NETWORK PROTOCOL – The protocol used to transport the peer data.
n. NOTES – Miscellaneous notes specific to the database point.

HOST PACK TEMPLATE

FACILITY:

HOST/HMI NAME

Host SCADA Configuration Information										
HOST TAGNAME	DB TYPE	HOST DESCRIPTION	ACTIVE STATE	INACTIVE STATE (0)	ALARM STATE	LO LO ALARM	LO ALARM	HI ALARM	HI HI ALARM	ALARM PRIORITY

		PLC Host Read/Write Area				PLC Intermediate Area				
HOST TAGNAME	PLC/RTU EQUIPMENT TAG	HOST I/O ADDR	HOST BIT NO	HOST PLC DATA TYPE	PLC SOFTWARE TAGNAME	INT I/O ADDR	INT BIT NO	INT DATA TYPE	PLC SOFTWARE TAGNAME	PEER DEVICE?

Field Interface Area						
HOST TAGNAME	PLC/RTU SOFTWARE TAGNAME *	FIELD DEVICE TAG *	POINT TYPE *	FIELD I/O ADDR *	FIELD BIT NO *	NOTES

LEGEND

	Engineer provides information
	Contractor provides information
	Systems Integrator/Programmer provides information
*	Common field to Field I/O List or Peer to Peer

TYPICAL FIELD INPUT/OUTPUT LIST

FACILITY:

PLC/RTU EQUIPMENT TAG: * *

RACK NAME	FIELD DEVICE TAG *	DESCRIPTION	CARD/ MODULE TYPE	POINT TYPE	DROP	RACK / BASE	SLOT	I/O POINT	CARD/MODULE TERMINALS

END OF APPENDIX B

SECTION 13390

APPENDIX C – AW Software Tagging Criteria

For signals associated with a stand-alone instrument:

PPPPPP_TTTTTT_IIII_QQ

Where,

- PPPPPP = Process Identifier (abbreviation for process fluid shown on P&IDs)
- TTTTTT = Function Descriptor (see Austin Water Software Tag Function Descriptors table)
- IIII = Unique Identifier (Loop numbers for instrument - limited to 4 characters)
- QQ = Qualifier (see Table 3-4, AW Primary Qualifier Codes)

For signals associated with a piece of equipment:

PPPPPP_TTTTTT_IIII_QQ
Where,

- PPPPPP = Equipment Code (as will be entered in INFOR)
- TTTTTT = Function Descriptor (see Austin Water Software Tag Function Descriptors table)
- IIII = Unique Identifier (Equipment ID - limited to 4 characters)
- QQ = Qualifier (see Table 3-4, AW Primary Qualifier Codes)

Function Descriptor Codes

The function descriptor code is a four character code used to indicate the specific equipment data being represented by the software point. Examples of equipment data include motor status, motor fault, motor start/stop commands, etc. The following tables list the function descriptor code available for use.

11/12/2013

Austin Water Software Tag Function Descriptors

Code	Type	Description
AAH	Input	High Analyzer Concentration Alarm
AAL	Input	Low Analyzer Concentration Alarm
ACNC	Input	Active Concentration
ACTP	Input	Analog Cell Temperature
ACTV	Input	Active or in Progress
AFB1	Input	Auto Flow Pace - Flow Meter 1
AFB2	Input	Auto Flow Pace - Flow Meter 2
AFBD	Input	Auto Flow Pace - Calculated Data
AFBF	Input	Auto Flow Pace - Flow Meter
ALCR	Input	Critical Alarm
ALMN	Input	Maintenance Alarm
ALARM	Input	Alarm
ALRT	Input	Alert
ALTSW	Input	Alternate Switch
AMPH	Input	High Amp
AMPL	Input	Low Amp
AMPS	Input	Amps
ASIL	Input	Motor Auto Stop Interlock
ATPT	Input	Attempt (used for substation transfer attempt Counter)
AUTO	Input	Auto
AVG	Input	Average Selected
BATA	Input	PLC Controller Battery A Alarm
BATB	Input	PLC Controller Battery B Alarm
BATGEN	Input	Generator Battery Alarm
BFTC	Input	Breaker Fail to Close
BFTO	Input	Breaker Fail to Open
BKAC	Input	Breaker Ok to Close
BKRC	Input	Breaker Closed
BKRO	Input	Breaker Open
BKWF	Input	Filter Backwash Sequence Failure Alarm
BKWH	Input	Strainer in Backwash
BKWM	Input	Filter in Manual Backwash Mode
BLCB	Input	Level Control Band
BYP	Input	Bypass (e.g., UPS)
CAPC	Input	Metering Pump Capacity
CALFLW	Input	Calculated Flow
CALLFL	Input	Call Fail
CBLA	Input	Global Communications Cable A Fault
CBLB	Input	Global Communications Cable B Fault
CFLA	Input	Communications Fail Channel A

Austin Water Software Tag Function Descriptors

Code	Type	Description
CFLB	Input	Communications Fail Channel B
CHCK	Input	Check Valve Fail to Open
CLFH	Input	Hypochlorite Generator High Cell Flow
CLFL	Input	Hypochlorite Generator Low Cell Flow
CLOCK	Input	PLC Clock
CLOS	Input	Close
CLRUN	Input	Call to Run
CLSD	Input	Limit Switch Closed
CLTP	Input	Hypochlorite Generator Cell Temperature
CMERAV	Input	Total Communication Errors Average
CMERLG	Input	Total Communication Good
CMERT	Input	Total Communication Errors
CMFL	Input	Communication Fail
CMPLD	Input	Last Poll Period
CMTRLT	Input	Total Comm Transmissions
CNRA	Input	Polymer Mixing Unit Centrifuge Not Run Alarm
COMERR	Input	Communication Error
CPRM	Input	Close Permissive
CPUSTA	Input	CPU Status Diagnostic
CRSW	Input	Current Switch
CRTM	Input	Time Until Next Cleaning
CYAC	Input	Cycle Timer Accumulated Time
CYCR	Input	Cycle Freq Timer
CYRM	Input	Remaining Time Until Next Cycle
CYSP	Input	Cycle Stop
CYST	Input	Cycle Start
DATAQL	Input	Data Quality
DAY	Input	PLC Clock Day of Month
DENS	Input	Chemical Density
DRAC	Input	Duration Timer Acc Val
DRRM	Input	Time Remaining Until Duration Ends
DRPS	Input	Duration Timer Reset
DSBL	Input	Disable
DSCH	Input	Discharge Rate
DSTC	Input	Discharge to Chlorine (App Point Chlorine Injection Vaults 1-4)
DSTF	Input	Discharge to Filters (App Point is Filtered Water Injection Vault)
DSTN	Input	Discharge to None (Application Point is Not Selected
DSWF	Input	Lime Slaker Discharge Weight Fault
EMRG	Input	Emergency (e.g., ATS in Emergency Power)

Austin Water Software Tag Function Descriptors

Code	Type	Description
ENAB	Input	Enable Control Status
ENAX	Input	Enable State X
ENBL	Input	Enabled (e.g., Auto Transfer at SUB enabled)
ESL	Input	Undervoltage Alarm
ESTP	Input	Emergency Stop
ET	Input	Voltage
EUH	Input	High Engineering Units
EUL	Input	Low Engineering Units
EXRNTM	Input	Extensive Run Time
EYEW	Input	Eyewash Station No. 1 Flow Switch High
FAIL	Input	Failure (e.g., PLC Fail
FAUL	Input	Fault (e.g., Lime Slurry Aging Tank Mixer Fault)
FAUT	Input	Motor Flow Pacing Auto Control Status
FDFA	Input	Flow Rate Difference Alarm (e.g., delta between calculated and actual flow)
FIT	Input	Flow Indicating Transmitter / Signal
FILFMX	Input	Lifetime Max Flow
FITOMX	Input	Today's Max Flow
FIYEMC	Input	Yesterday's Max Flow
FLOW	Input	Flow/Flow Mode
FLWO	Input	Flow Pacing Selection Reset
FLWC	Input	Hypochlorite Generator Cell Flow
FLWX	Input	Flow X Selected for Flow Pacing
FQAC	Input	Frequency Timer Accumulated Value
FQICUR	Input	Current Day Flow Total
FQILF	Input	Lifetime Flow Total
FQIPRE	Input	Previous Day Flow Total
FQITOT	Input	Calculated Flow Total
FQPS	Input	Frequency Timer Preset
FRDH	Input	Flow rate difference high (when instrument flow compared to calculated flow)
FRFS	Input	Fail to reach flow setpoint
FRPS	Input	Fail to reach position setpoint
FSL	Input	Low Flow Switch
FSP_ACC	Input	Accumulated Fail to Stop Time
FSRT	Input	Fail to Start
FSTP	Input	Fail to Stop
FTAC	Input	Fail Timer Accumulated Value
FTC	Input	Fail to Close
FTO	Input	Fail to Open
FTPS	Input	Fail Timer Preset
FUSB	Input	Fuse Blown

Austin Water Software Tag Function Descriptors

Code	Type	Description
FXRM	Input	Fixed Rate Mode (vs. Level Rate Mode)
GRND	Input	Ground Fault Alarm
HDLS	Input	Headloss (e.g., filters)
HDWR	Input	Hardware
HLTH	Input	PLC Power & Scan Health Status
HOLD	Input	Hold Calculation Command
HOPP	Input	Hopper
HOUR	Input	PLC Clock Hour (Military) from Host
HTBT	Input	Heartbeat (Used for communication check)
HRUN	Input	High Speed Running Status
HSTR	Input	Motor High Speed Start Command
HVR	Input	Voltage High (e.g., battery)
ILCK	Input	Interlock
INIT	Input	Total Run-time Alarm/Hours Reset
ISRV	Input	In Service Command
KILK	Input	Key Interlock
KQAH	Input	Motor Service Alarm
KQI	Input	Runtime
KQI1	Input	Service Runtime
KQI2	Input	Lifetime Runtime
KQI3	Input	Runtime Since Start
KQILF	Input	Lifetime Runtime
KQIMN	Input	Monthly Runtime
KQIMP	Input	Previous Monthly Runtime
KQITO	Input	Today’s Runtime
KQIYE	Input	Yesterday’s Runtime
KWHMG	Input	KWH / MG Today
KWHMG	Input	KWH / MG Yesterday
LAUT	Input	Motor Local Auto Control Status
LAGPMP	Input	Lag Pump Run
LCRM	Input	Equipment in Local or Remote
LDRA	Input	Level Decline Rate Alarm
LDRD	Input	Level Decline Rate Difference
LEAD	Input	Equipment is Load
LEAK	Input	Leak indication (.g., high gas concentration)
LEVEL	Input	Level
LGPSTS	Input	Lag Pump Starts Today
LI2DMN	Input	Minimum Level from 2 Days ago
LI2MDX	Input	Maximum Level from 2 Days ago

Austin Water Software Tag Function Descriptors

Code	Type	Description
LIT	Input	Level Indicating Transmitter
LITOMN	Input	Today's Level Minimum
LITOMX	Input	Today's Level Maximum
LIWF	Input	Lime Slaker Lime Inlet Weight Fault
LIYEMN	Input	Yesterday's Level Minimum
LIYEMX	Input	Yesterday's Level Maximum
LMAN	Input	Motor Local Manual Control Status
LMWT	Input	Lime Weight
LOAL	Input	Lockout Alarm
LOCK	Input	Lockout
LOCL	Input	Local
LOGC	Input	Controller A/B Logic Mismatch
LRUN	Input	Low Speed Running Status
LSHH	Input	Level Switch Hi-Hi
LSH	Input	Level Switch Hi
LSLL	Input	Level Switch Lo-Lo
LSL	Input	Level Switch Lo
LSTR	Input	Motor Low Speed Start Command
LVHH	Input	Level Hi-Hi
LVLB	Input	Level of Brine
LVLL	Input	Level Lo-Lo
LVLN	Input	Level of Salt
LVLQAI	Input	Level Data Quality
LVLX	Input	Level X Selected
LVR	Input	Voltage Low (e.g., battery)
LVRM	Input	Level Rate Mode (vs. Fixed Rate Mode)
LY	Input	Bubbler / Level Transmitter Fail
MAN	Input	Manual
MDBBD	Input	Modbus Baud
MDBDL	Input	Modbus Data Length
MDBDP	Input	Modbus Data Parity
MDBRT	Input	Modbus Retries
MDBSB	Input	Modbus Stop Bit
MDBTO	Input	Modbus Timeout
MDFT	Input	Frequency Timer Mode
MDSP	Input	Sludge Pump Mode (UFC Residual)
MIN	Input	Clock Minute
MLR	Input	Motor Lockout Relay
MNFL	Input	Manual Flow
MNPS	Input	Manual Position Mode

Austin Water Software Tag Function Descriptors

Code	Type	Description
MNSP	Input	Manual Speed SP Mode
MNTN	Input	Maintenance Mode
MODALN	Input	Module (IO) Alarm
MODBD	Input	Modem Baud
MODDL	Input	Modem Data Length
MODDP	Input	Modem Data Parity
MODE	Input	Status or Mode
MODSB	Input	Modem Stop Bit
MONTH	Input	Clock Month
MPR	Input	Motor Protector Relay Alarm
MSIL	Input	Motor Manual Stop Interlock
NSH	Input	Hi Torque Alarm
NCR	Input	No Charge (e.g., battery)
NDST	Input	Output to No Destination (e.g., metering pumps)
NGR	Input	Negative Ground (e.g., battery)
NLRM	Input	None in Level Rate Mode Alarm (UFCs)
NMSTOP	Input	Normal Stop Cycle
NORM	Input	Normal (e.g., ATS Normal Power
NOTAVL	Input	Not Available
NOTK	Input	Standby Controller Not On LAN
NSH	Input	Hi Torque Switch
NSHH	Input	Hi-Hi Torque Alarm
NSHHH	Input	Drive Motor Cut Out Torque Alarm
NUMBR	Input	Telephone Number
OAAF	Input	Operator Adjustable Adjustment Factor (e.g., metering pump dose calculations)
OFAC	Input	Cycle Timer Off Accumulated Valve
OFF	Input	Off Status
OFFX	Input	Disable State X Command
OFLN	Input	Offline
OFPS	Input	Cycle Timer Off Preset
ON	Input	On / Running
ONAC	Input	Cycle Timer On Accumulated Value
OPEN	Input	Open Status
ONPS	Input	Cycle Timer On Preset
OPRM	Input	Open Permissive
OORAIX	Input	Out of Range for Analog Input Channel X
OORAOX	Input	Out of Range for Analog Output Channel X
OSRV	Input	Out of Service Command
OVLD	Input	Overload

Austin Water Software Tag Function Descriptors

Code	Type	Description
PBSP	Input	Push Button Stop (e.g., LSPS)
PBST	Input	Push Button Start (e.g., LSPS)
PDAH	Input	High Differential Alarm
PFLD	Input	Power Factor Lead
PFLG	Input	Power Factor Lag
PFOL	Input	Power Factor Capacitor Overload
PGR	Input	Positive Ground Detect (e.g., battery charger)
PICK	Input	Pickup Coil
PING	Input	PING (e.g., PLC PING status)
PIT	Input	Pressure Indicating Transmitter
PMPX	Input	Pump X Selected
PNLF	Input	Front Panel Open
POLLCD	Input	Poll Command
POLLST	Input	Last Poll Status
PRTY	Input	Chemical Purity
PRMA	Input	Controller A is Primary
PRMB	Input	Controller B is Primary
PROC	Input	Motor Process Permissive
PSAC	Input	Parallel Source Active (e.g., SUB1)
PSAL	Input	Parallel Source Alarm (e.g., SUB1)
PSH	Input	Pressure Switch High
PSL	Input	Pressure Switch Low
PSTR	Input	Motor Pending Startup Status
PWRA	Input	Power Fail A
PWRB	Input	Power Fail B
QFEF	Input	Filters Effluent Flow Dosage Point
QRWF	Input	Raw Water Flow to Clarifiers Dosage Point
RAIXHD	Input	RTU Analog Point ‘X’ Health Diagnostic
RALL	Input	Remote Auto Lead-Lag Control Mode
RALM	Input	Resettable Alarm
RAPR	Input	Remote Auto Percentage mode
RAUT	Input	Motor Remoter Auto Control Status
RDY	Input	Equipment Ready Status
REFVLP	Input	Reference Voltage Positive
REFVLN	Input	Reference Voltage Negative
RIOP	Input	Global Communications RIO Health Fault
RKXFLT	Input	Rack Fault for Rack No. ‘X’
RMDXHD	Input	RTU Module ‘X’ Health Diagnostic Status
RMOT	Input	Remote
RSET	Input	Alarm Reset

Austin Water Software Tag Function Descriptors

Code	Type	Description
RSME	Input	Resume Calculation Command
RTHI	Input	Runtime Hi Alarm
RTMH	Input	Rectifier High Temp Hi
RTODDT	Input	RTU Time Of Day – Date
RTODDY	Input	RTU Time Of Day – Day
RTODHR	Input	RTU Time Of Day – Hour
RTODMN	Input	RTU Time Of Day – Minute
RTODSC	Input	RTU Time Of Day – Second
RTODYR	Input	RTU Time Of Day – Year
RTS	Input	Return to Service
RUNA	Input	Running Alarm
RUNC	Input	Close Contactor is Energized (e.g., electric actuator)
RUNN	Input	Motor Running
RUNO	Input	Open Contactor is Energized (e.g., electric actuator)
RUNTIME	Input	Service Time Preset/Reset Value
RVSF	Input	RVSS (Reduced Voltage Solid-state Starter) Fault
RXXSTA	Input	Rack 0 Slot XX Status (OK)
S908	Input	Global Communications Health Fault
SAFE	Input	Motor Safety Permissive (Future)
SALM	Input	Alarm Exists
SAUT	Input	Motor Speed Auto Control Status
SBYA	Input	Controller A is Standby
SBYB	Input	Controller B is Standby
SCAN	Input	PLC Scan Time
SCLB	Input	Scale Buildup (Lime Slaker)
SCLH	Input	Scale Buildup High Alarm (Lime Slaker)
SEC	Input	Clock Seconds
SELX	Input	State X Selected
SHDN	Input	Shutdown Alarm
SHOL	Input	Space Heater Overload
SILK	Input	Motor Stop Interlock
SLTL	Input	Salt Tank Low
SOFF	Input	Selector Switch in OFF
SON	Input	Selector Switch in ON
SPRM	Input	Start Permissive
SRAM	Input	PLC State RAM
ST	Input	Speed Feedback
STBY	Input	Stand-by Status
STDN	Input	Shutdown

Austin Water Software Tag Function Descriptors

Code	Type	Description
STEP	Input	Sequence Step
STLF	Input	Lifetime Starts
STRK	Input	Stroke
STRT	Input	Motor Start
STOP	Input	Motor / Valve Stop
STSEXD	Input	Starts Exceeded
STSEXB	Input	Starts Exceeded Bypassed
STTO	Input	Today's Starts
STYE	Input	Yesterday's Starts
SUCC	Input	Success
SURG	Input	Surge Alarm
SWAP	Input	PLC Swap Over Command
SYNC	Input	Sync Check Relay
TALM	Input	Temperature Alarm
TDAC	Input	Time Delay Off Accumulated Value
TEMP	Input	Temperature
TIMSTP	Input	Time Stamp
TGON	Input	Tagout On
TOC	Input	Truck Operated Contact (Vacuum Circuit Breaker)
TODFUL	Input	Time of Day Events Full
TODNUM	Input	Time of Day Events Number
TODSYN	Input	Synch RTU Clock to FEP
TOKN	Input	Token Rotation Time in secs
TOTL	Input	Total
TRBL	Input	Trouble (Malfunction) Alarm
TSH	Input	High Temperature Switch
TSL	Input	Low Temperature Switch
UFRV	Input	Unit Filter Run Volume
UPSB	Input	UPS Low Battery
UPSF	Input	UPS Fail
VFDA	Input	VFD Alarm
VFDT	Input	VFD Temperature Alarm
VFTC	Input	Valve Fail to close
VFTO	Input	Valve Fail to open
VSH	Input	High Vibration
VSHH	Input	High High Vibration
VSL	Input	Low Vibration
WALM	Input	Weight Alarm

Austin Water Software Tag Function Descriptors

Code	Type	Description
WARN	Input	Warning
WIWF	Input	Water Inlet Weight Fault (Lime Slaker)
WSFL	Input	Weight Sensor Fault (e.g., Lime Slurry Aging Tank)
WY	Input	Weight Tared
XA	Input	Surge Suppressor Alarm
XFER	Input	Transfer Relay (e.g., initiates SUB1 transfer algorithm)
XHK	Input	Dosage Set point
XHLD	Input	Hold Calculation Status
XMTECD	Input	Transmit Error Code
XMTEND	Input	Transmit Error Node
XS	Input	General Switch Input
XSRV	Input	Filter In Service Status
XTND	Input	Filter Extend Backwash Notification
XTON	Input	Filter Extend Backwash On Status
XTOP	Input	Stop
XQI	Input	Current Day Start Count
XYSN	Input	Module Health Drop X Rack Y Slot N
YEAR	Input	Clock Year
ZA	Input	Valve Fail Alarm
ZDO	Input	Zero Dropout Value
ZS	Input	General Switch Input
ZSC	Input	Position switch close
ZSO	Input	Position switch open
ZT	Input	Position Feedback
AHK	Output	Remote Analyzer Setpoint
CLOS	Output	Equipment Close Coil
CYPS	Output	Cycle Preset Time Setpoint
DRPS	Output	Duration Preset Time Setpoint
FHK	Output	Flow Setpoint
FHKx	Output	Flow Setpoint, where x is a unique digit (when multiple setpoints used)
FIC	Output	Flow Controller Output
HSTR	Output	High Speed Start Coil
HXTP	Output	High Speed Stop Coil
KQC	Output	Runtime Reset Value
LHK	Output	Level Setpoint
LHKx	Output	Level Setpoint, where x is a unique digit (e.g., used in multi-level setpoints for tanks)

Austin Water Software Tag Function Descriptors

Code	Type	Description
LSTR	Output	Low Speed Start Coil
LXTP	Output	Low Speed Stop Coil
MNRTSP	Output	Minimum Pump Runtime Setpoints
OFFSP	Output	Off Setpoint
ONFR	Output	Online Fixed Rate Mode Command
ONLR	Output	Online Level Rate Mode Command
ONSP	Output	On Setpoint
OPEN	Output	Equipment Open Coil
RNTRST	Output	Runtime Reset
RSET	Output	Reset Command
RST1	Output	Reset Service Runtime Command
RST2	Output	Reset Life Runtime Command
RVAL	Output	Equipment Runtime Preset Value
SHK	Output	Speed Setpoint
SHKx	Output	Speed Setpoint, where x is a unique digit (when multiple setpoints used)
SPBD	Output	Stop Blowdown Command
SRINSP	Output	Service Alarm Interval Setpoint
STBD	Output	Start Blowdown Command
STOP	Output	Stop Command
STRT	Output	Start Command
TGDT	Output	Tagout Date Setpoit
TGRN	Output	Tagout Reason Setpoint
TGRS	Output	Tagout Reset Command
TGST	Output	Tagout Set Command
TGTM	Output	Tagout Time Setpoint
TGUS	Output	Tagout User Setpoint
XFER	Output	Transfer Coil
XHK	Output	Dosage Setpoint
XHKx	Output	Dosage Setpoint, where x is a unique digit (when multiple setpoints used)
XRUN	Output	Motor Run / Stop Coil
XTOP	Output	Motor Stop Coil
ZHK	Output	Position Setpoint
ZHKx	Output	Position Setpoint, where x is a unique digit (when multiple setpoints used)
ZVC	Output	Valve Close Command
ZVO	Output	Valve Open Command
ZVC	Output	Valve Open / Close Coil

Table 3-4
Primary Qualifier Codes

Qualifier Code	Description
I	Field inputs to PLC.
O	Field outputs from PLC.
F	Filtered values/coils (used for existing software tag names only).
HI	Host inputs read from PLC.
HR	Host register read from/written to PLC.
M	Logic modified values/coils.
P	Peer-to-Peer points.
S	Scaled values.
DW	Host write to data source.
DR	Host read from data source.
PB	Primary Block.
CSB	Secondary Block.
LHI	Local Host (OIU) inputs read from PLC.
LHO	Local Host (OIU) outputs written to PLC.
LHR	Local Host (OIU) register read / wire to PLC

SECTION 14620

CRANES, MONORAILS AND HOISTS

PART 1 GENERAL

1.01 SUMMARY

A. Furnish, install, and place in service all cranes, monorails and hoists shown on PLANS and as specified herein.

1.02 RELATED REQUIREMENTS

A. PLANS show general arrangement, location, and basic dimensions. Attachment "A" to this Specification Section gives performance and design requirements.

B. Related work as called for on PLANS or specified 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.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	Load Ratings and Fatigue Life for Ball Bearings

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B30.11	Safety Standard for Monorail Systems & Underhung Cranes
ANSI B30.16	Safety Standard for Overhead Hoists
ANSI MH27.1	Underhung Cranes and Monorails

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A36	Standard Specification for Structural Steel

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1	Structural Welding Code - Steel

CRANE EQUIPMENT MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA No 74	Specification for Top-Running and Under-Running Single Girder Electric Overhead Traveling Cranes

HOIST MANUFACTURERS INSTITUTE (HMI)

HMI 100	Standard Specification for Wire Rope Hoists

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

OSHA 1910.179	Overhead and Gantry Cranes

1.04 - 1.05 (NOT USED)

1.06 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. Dimensioned installation drawings, and construction material designations by ASTM Standards.
      b. Layout plan(s) and details for supports, connections, splices, and end/safety stops.
   2. Operation and Maintenance Manuals.
   3. Certificate of Conformance as required in Paragraph 1.07 - Quality Assurance.
   4. Furnish certified report prepared by manufacturer’s technical representative certifying satisfactory installation, operation and in-service placement of units.

1.07 QUALITY ASSURANCE

A. All design computations and detail drawings are to be prepared by or under the direct supervision of a Professional Engineer registered in the State of Texas. Provide certificate signed and sealed by same engineer stating that the computations and drawings are in conformance with design criteria.

B. Standardization: All like equipment to be obtained from single manufacturer.

C. 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.

D. Provide guards, stops, and other features necessary to comply with OSHA regulations.

E. Welding to be performed by welders certified in accordance with the latest edition of AWS D1.1. Certification to be dated within the previous six months of receiving notice to proceed. All welding to be in compliance with AWS D1.1.

1.08 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 (couplings, nuts and bolts, gaskets, etc.) are to be shipped in crates that are clearly marked as to contents.

B. Handling and Unloading: Unload and handle equipment in accordance with manufacturer’s instructions. Handle unit to prevent damage during unloading and installation. Follow manufacturer’s instructions on lifting and setting.

C. Storage
   1. Store in an area that will avoid damage due to traffic. Store and temporarily support equipment prior to installation in strict accordance with the manufacturer’s recommendations and instructions.
   2. Protect the equipment from being contaminated by dust, dirt, vibration and moisture.
   3. Rotate all shafts that have bearings on at least a monthly basis.

1.09 - 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURER(S)

Per Attachment “A”.

2.02 MATERIALS AND/OR EQUIPMENT

A. General:
   1. Steel used in fabrication of cranes to be per ASTM A36.
   2. Crane classification per Attachment “A”.

B. Bridge Cranes:
   1. General:
      a. Cranes to be a single girder, top running, end braced, dual motor driven.
      b. Structural and mechanical components to meet or exceed the requirements of CMAA No. 74.
      c. Traveling bridge to be driven by an electric motor with power supplied from a traveling shoe on a solid bus bar as manufactured by Duct-O-Bar Company, or equal.
      d. Hoist and trolley to be driven by an electric motor with power supplied from flat festoon cables and connectors by Duct-O-Wire Company, or equal.
      e. Hoist to be geared type with wire rope lift and drop forged steel hook with safety latch and 360-degree swivel.
   2. End trucks to be two heavy structural channel shapes securely ribbed and braced with spacing channels or yokes welded into a rigid one-piece unit. End truck design to conform to CMAA No. 74 with the wheelbase greater than or equal to, 1/7 of the crane span.
   3. Crane wheels to be forged steel, flanged, tread hardened to 300 to 500 Brinell, with tapered tread on drive wheels to avoid skewing when traveling along runway. Provide anti-friction ball bearings to absorb thrust between wheel and end trucks with pressure type lubrication fittings.
   4. Bridge to be a structural beam shaped to allow the full weight to rest vertically on end trucks with clip and extra large gusset plates to form a rigid bolted connection. Deflection is not to exceed $1/600^{th}$ of span. Design bridge girder to resist vertical, lateral, and torsional forces and stresses as defined by CMAA No. 74.
   5. Crane rails to conform to the ASCE Specifications and to be provided with fixed end stops. End stops to be designed to stop crane traveling at full speed with a design load.
   6. Top of runway rail to top of girder is not to exceed 3′-4″.
   7. Crane rail to be bolted to its supporting structural member (wide flange/channel) using hook bolts. Hook bolt diameter and spacing along rail to be per manufacturer’s recommendation.
   8. Dual motor driven bridge travel to be accomplished by delivery of power to each end truck by its own drive motor operating through an enclosed oil-tight, helical gear reduction. Open wheel gears and pinions to be machine cut to provide high strength. Control pushbutton station (including hoist and trolley controls) to be suspended from the bridge off a steel track so the crane can be controlled from any length along the bridge span.
   9. Provide and install a sign indicating crane capacity.

C. Monorails:
   1. Provide monorail systems as indicated on the PLANS, complete with supports and stops, in accordance with ANSI MH27.1.
   2. When the size of the monorail is not indicated on the PLANS:

a. Monorail to be designed with a minimum safety factor of 5 based on the minimum ultimate strength of the material.
b. The load on the lower load carrying flange to be assumed to be at a point central with the wheel tread.
c. The ratio of span to top flange width not to exceed 60:1.
d. The total monorail deflection while supporting the maximum live load not to exceed 1/600th of the span.
e. An impact factor to be included in design calculations based on the full live-load rated capacity of the unit. The impact load to be considered as being equal to 0.5% of the rated load for each foot per minute of full load hoisting speed with a minimum allowance of 15% and a maximum of 25%.

3. Monorail sections to be installed with top flange tie plate and web bolted, welded, or hot riveted couplings at rail joints to provide flush and level connections, with maximum gap between adjacent ends at load carrying flange not exceeding 1/16″.
4. All necessary clamps, hanger rods, and other fittings from which a monorail is suspended to be provided as part of the overhead monorail system. If connection details of monorail to structure are not shown on PLANS, submit plans and details for connections to structure. Provide fittings with means for adjusting the monorail vertically to provide for level erection, and laterally for setting accurate runway gauge with provision for an additional 1/2″ vertical adjustment after the system has been in operation.
5. No holes are permitted in any part of the building structure without written permission from the ENGINEER.
6. Curves (when indicated on PLANS) to be of such radius to permit operation of the trolley or carrier without binding. Curves to be accurately formed to true radius.
7. Monorail sections are to be straight and true with saw-cut ends. Holes in track sections are to be factory punched or drilled.
8. Track end stops are to be of the bolted type and capable of withstanding the impact of fully loaded hoist/trolley traveling at 50% of the rated full load speed. End stops are to engage trolley frame, not wheels.

E. Hoists:

1. Hoists to be wire rope or chain type. For wire rope, to have iron drums machine grooved to assure proper reeving throughout the entire length of the lift to prevent cable from overriding the drum. Capacity to permit at least two wraps of cable or chain to remain on drum when the hook has reached the lowest point of its rated lift.
2. Gears:
   a. Triple reduction gears of alloy steel forgings, heat treated, hardened, and ground.
   b. Serrated spline shaft connection.
   c. Gear train to be splash-lubricated or oil-bathed.
3. Bearings: “Lifetime” double sealed ball bearings.
4. Brakes:
   a. Disc-Type Motor Brake
      1) Positive acting brake to stop motor instantly when power is cut off.
      2) Mechanism to be enclosed to protect from dirt, water, and oil.
      3) Brake to hold load if power fails.
   b. Roller-Clutch Type Load Brake
      1) Mount on output side of reduction unit.
      2) To act automatically whether power is on or off.
      3) Brake to hold load if power fails.
5. Hook: Drop forged steel hook with safety latch to revolve 360° on anti-friction thrust bearings.

6. Hook Travel and Load Limiting Devices:
   a. Provide mechanical device to prevent hook over-travel.
   b. Load limiting device to prevent damaging overloads with slip-clutch operation, and to prevent raising a load in excess of rated capacity.
7. Hoists to have upper and lower lift limit switches. Hoists to be provided with overload protection to allow hoist motor to turn without lifting if load is in excess of hoist's rated capacity.
8. Load blocks and hooks to be enclosed, safety-type construction with completely enclosed sheaves. Sheaves to rotate on anti-friction ball bearings.
9. Hoists to meet requirements of HMI 100.
10. Motor and Drive Assembly: Per Attachment "A".

F. Trolleys:
1. Track:
   a. Monorail Track: Standard beam of sizes indicated on drawings.
   b. Shop fabricate all curves for either track or switches to radius indicated.
   c. Erect track level throughout, with section ends machined fitted and spliced with web-type or other designed couplings to provide flush level connections. Maximum gap between adjacent ends not exceeding 1/16 inch (1.6 mm).
2. Trolley manufacturer to verify that the monorail beam size is the correct size and shape for the trolley.
3. Wheels: Flanged type, fabricated from cast iron or forged steel with hardened (425-480 Brinell) and accurately machined treads for concentricity with axle.
4. Bearings: Tapered roller bearings to absorb radial and thrust loads. Permanently lubricated and sealed. Minimum B_{10} life of 5,000 hours per ABMA.
5. Axles: Precision machined from high strength, heat-treated steel. Rigidly supported from the side frame yoke and mounted so that the wheels are set at the same angle as the monorail bottom flange.
6. Side Yokes: Fabricated steel to support axles and lug for hoist. Frame to extend past wheels to act as a stop to prevent wheels from impacting monorail end-of-travel stops. Design of side frames to be such that all wheels remain in contact with the load carrying flange of the monorail.
7. Furnish trolley with lug for mounting portable hoist.
8. Both sides of trolley to receive signs or other means of identification to indicate the maximum load capacity of the trolley.
9. Motor and Drive Assembly: Per Attachment "A".

G. Electrical and Controls:
1. Controls to consist of all necessary electrical contactors, relays, transformers, and pendant push-button station. The control unit to be reversing type and have three phase overload protection. The pilot control circuit to the push-button station to be reduced to 24 volts. Overload protection to be automatic reset type. A mainline magnetic contactor to be included as an emergency stop safety feature and operated by means of a pendant push-button at the operator's location.
2. Electric controls to be enclosed in NEMA 4X stainless steel enclosures as shown on the PLANS. Furnish control enclosure with a door-interlocked disconnect switch.
3. The control pendant is to be a NEMA 4X enclosure suspended by a steel cable 4′-6″ above the operating floor and 4′-8″ from the center of the hoist rail. Provide grounding wire to the hoist frame in the pendant cable. Control pendant to be manufacturer's standard unit with push buttons to accommodate the number of control points for the crane/hoist.
4. Provide 4 Bar, conductor bar system complete with hangers, brackets, end feeds, and collectors.
5. Motors:

a. Motors for trolleys and hoists to be high slip, high torque type manufactured to meet NEMA standards and rated to operate hoist at full load without overheating.
b. Operating voltage per Attachment “A”.
c. Duty Rating: 30-minute hoist duty motor.
d. Insulation: Class B insulation rated for a 75°C rise over 40°C ambient.
e. Motors to have service factor of 1.15.
f. Enclosure: TENV

2.03 FABRICATION (NOT USED)

2.04 SOURCE QUALITY CONTROL

A. Prior to shipment, equipment to be tested at manufacturer’s plant to demonstrate the suitability of the equipment as a part of the complete installation. Test each hoist to demonstrate ability to lift the rated load without overheating or damage. Test all cranes to demonstrate proper travel. Test unit fully in accordance with ANSI B30.11 and ANSI B30.16. Submit a written test report certifying full details of test methods and procedures, and results.

PART 3 EXECUTION

3.01 - 3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Follow manufacturer’s printed instructions and approved practice for installation of equipment. Lubricate and make units ready for operation.

B. Jib cranes are to be installed level and plumb.

C. Bridge Cranes: Rails are to be level, straight and parallel within ±1/8″.

D. Monorails: Rails are to be level and straight within ±1/8″.

3.04 (NOT USED)

3.05 FIELD QUALITY CONTROL

A. Manufacturer’s Service:
1. Furnish services and training required in Section 01445, “Manufacturers Field Services”.

B. Placing in Service:

1. After erection and inspection, test the complete crane and/or monorail system, hoist, and trolley to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacturing, installation, and workmanship. Rectify all deficiencies identified during the test and retest the system until satisfactory.
2. Contractor shall furnish test loads, operating personnel, instruments, and other apparatus necessary to conduct the field tests. Record test data on forms provided by the manufacturer. At a minimum record operating and startup current measurements for electrical equipment, operating temperatures, hoist speed, trolley speed, and lift distance.

a. No-load Test:

1) Hoist: Raise the load hook the full operating lift distance and verify satisfactory operation of hoist, upper limit switches, lower limit switches, and the hoist speed.

2) Trolley: Operate the trolley assembly the full length of travel in both directions. Verify satisfactory operation and trolley speed.

b. 125 Percent Rated Load Test:

1) Hoist Static Test: Raise test load approximately 1ft above the floor and hold for 10 minutes. Observe load lowering that may occur which indicates malfunction of hoisting component or brake operation. Lower the test load to the floor until the hoist line is slack.

2) Hoist Dynamic Test: Raise the test load to approximately 5ft above the floor, hold for 1 minute and then lower back to the floor. Stop the test load at least once while lowering to confirm proper brake operation.

3) Trolley Test: With the test load hoisted to a height of 1ft above the floor, operate the trolley the full length of travel, in both directions. Confirm the trolley stops are provided and function to stop the trolley in the specified position. Coordinate stop locations as shown on the PLANS and with all adjacent equipment.

3.06 - 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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.

ATTACHMENT "A"

A. Operations Building Monorail Crane

1. Monorail Data:
   a. Quantity: 1
   b. Type: Bottom Running Monorail with Manual Chain Hoist
   c. Capacity (tons): 1
   d. Minimum required vertical distance from bottom of hook to top of platform (426.83 ft-msl): 6.5 ft

2. Hoist and Trolley Data:
   a. Capacity (tons): 1
   b. Maximum Lift (ft): 20
   c. Type: Manual
   d. Headroom design (ft): As required to meet minimum vertical distance
   e. Typical Make and Model: Harrington HAR-PT010

END OF SECTION

SECTION 15040

AIR SCRUBBER / AIR PURIFIER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-zone air filtration systems.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.3 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. Product Data: For each air-handling unit indicated.

1. Unit dimensions and weight.
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fans:

a. Certified fan-performance curves with system operating conditions indicated.
b. Certified fan-sound power ratings.
c. Fan construction and accessories.
d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified media filter-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.

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

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

3. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
4. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
5. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, and shall be listed and labeled by ARI.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. BioClimatic

2. Camfil

3. Circul-Aire

2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Frame: 1 inch extruded aluminum

2. Walls: 1 inch-thick double wall insulated panels. Interior panels shall be minimum 18 gauge aluminum. Exterior panels shall be minimum 16 gauge aluminum.
3. Casing Joints: Sheet metal screws or pop rivets.
4. Sealing: Seal all joints with water-resistant non volatile sealant compound
5. Insulation: 1 inch-thick foam with minimum R-8 thermal resistance.
6. Filter tracks: Extruded aluminum with pile seal.
7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

8. Access Doors:

    a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
    b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    c. Fabricate windows in doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
    d. Latches: Vent-lock type.
    e. Size: As required for removal and replacement of filter media and maintenance components..

9. Locations and Applications:

    a. Fan Section: Inspection and access panels.
    b. Access Section: Doors.
    c. Filter Section: Inspection and access panels large enough to allow periodic removal and installation of filters.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

    a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
    b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.

4. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized-steel sheet or 0.032-inch-thick aluminum sheets; select metal compatible with casing.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

        1) Fabric Minimum Weight: 26 oz./sq. yd..
        2) Fabric Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
        3) Fabric Service Temperature: Minus 40 to plus 200 deg F.

C. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

E. Fan Shaft Bearings:

1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of 120,000 hours according to ABMA 9.

F. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.

G. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section 15058 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. Provide one of the following:
    a. Adjustable direct drive EC Motor.
    b. Inverter duty for connection to manufacturer provided VFD. Rate VFD enclosure for IP54 resistance.
3. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
4. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.

2.4 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

B. Disposable Pre Filters:

1. Factory-fabricated, viscous-coated, flat-panel type.
2. Thickness: 2 inches.
3. Arrestance (ASHRAE 52.1): 80.
4. Merv (ASHRAE 52.2): 8.
5. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
6. Frame: aluminum, with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

C. Disposable Final Filters:

1. Factory-fabricated, viscous-coated, flat-panel type.
2. Thickness: 2 inches.
3. Arrestance (ASHRAE 52.1): 80.
4. Merv (ASHRAE 52.2): 14.
5. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
6. Frame: aluminum, with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

D. Cartridge type Media Module Filters:

1. Factory-fabricated cartridge type. Refillable or replaceable.
2. Efficiency: 80%
3. Media type: Carbon
4. Initial Resistance: 3.6 inches wg
5. Recommended Final Resistance: 4 inches wg
6. Mounting Frames: 16-gauge alumizied steel with gasketed dual access door and track for cartridge cylinder filters.

E. Filter Gage:

1. 3-1/2-inch- diameter, diaphragm-actuated dial in metal case.
2. Vent valves.
3. Black figures on white background.
4. Front recalibration adjustment.
5. 2 percent of full-scale accuracy.
6. Range: 0- to 4.0-inch wg.
7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch aluminum tubing, and 2- or 3-way vent valves.

2.5 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.

B. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for HVAC."
    b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Size dampers for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
    b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
    c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
    d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
    e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
    f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

6. Coupling: V-bolt and V-shaped, toothed cradle.
7. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
8. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
9. Power Requirements (Two-Position Spring Return): 120-V ac.
10. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
11. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
12. Temperature Rating: Minus 22 to plus 122 deg F.
13. Run Time: 30 seconds.

2.6 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Media Filter Performance Rating:

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting: Install units on using restrained spring isolators. Secure units to anchor bolts installed in platform. Comply with requirements for vibration isolation devices specified in Division 15 Section 15074 "Vibration Controls for HVAC."

1. Minimum Deflection: 1/2 inch.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

E. Connect duct to units with flexible connections. Comply with requirements in Division 15 Section 15320 "Duct Accessories."

3.2 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 15040

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SECTION 15053

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 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. Concrete bases.
10. Supports and anchorages.

1.2 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 and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Welding certificates.

B. Submit shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

1.4 QUALITY ASSURAN CE

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

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. 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.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 15 piping Sections 15181 Hydronic Piping and 15183 Refrigerant Piping for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

A. Refer to individual Division 15 piping Sections 15181 “Hydronic Piping” and 15183 “Refrigerant Piping for Pipe”, tube for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12.

G. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.
2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.3 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 Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

F. 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.

2.4 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.

D. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.5 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.

2.6 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

3.1 HVAC DEMOLITION

A. 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. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 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. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 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.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402, for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
3. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 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.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to applicable codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."

3.7 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.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 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.

3.10 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 15053

SECTION 15058

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

1.3 SUBMITTALS:

A. Submit shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with

indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION

3.1 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 15058

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SECTION 15060

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Equipment supports.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

C. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Equipment supports.

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

E. Welding certificates.

1.4 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel .

C. Copper Pipe Hangers:

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type , stainless- steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.5 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.6 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

G. Install lateral bracing with pipe hangers and supports to prevent swaying.

H. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

J. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.

3. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
4. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
5. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.7 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.

3.8 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 15060

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

B. Provide all tools, supplies, materials, equipment, and labor necessary for the design, furnishing, construction, and installation of all pipe supports, hangers, guides, and anchors shown, specified, or required for a complete and operable piping system.

C. Piping supports for pipe 30″ and larger have been designed for the piping shown. Any modification to the piping, including the addition of flexible joints where not shown will require review and approval of the support system.

D. The absence of pipe supports, restraints and related details for pipes smaller than 30″ on the PLANS does not relieve the CONTRACTOR of the responsibility for providing them. Pipe supports and restraints shown on the PLANS, if any, are shown only to convey the design intent or where specific types and locations are required for a particular location and are not intended to represent a complete support system.

E. Piping supports for plumbing piping and specialties are not covered by this Specification.

1.02 RELATED REQUIREMENTS

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

1.03 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

A123	Specifications for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
A 380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
A575	Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
A 967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

MANUFACTURER'S STANDARDIZATION SOCIETY (MSS)

SP-58	Pipe Hangers and Supports - Materials, Design, and Manufacture.
SP-69	Pipe Hangers and Supports - Selection and Application.
SP-89	Pipe Hangers and Supports – Fabrication and Installation Practices.
SP-90	Guidelines on Terminology for Pipe Hangers and Supports.

FEDERAL SPECIFICATIONS (FS)

WWH-171 Hangers and Supports, Pipe.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

B31.1 Power Piping

UNDERWRITER'S LABORATORIES, INC. (UL)

UL-203 Pipe Hanger Equipment for Fire Protection Service.

1.04 (NOT USED)

1.05 SYSTEM DESCRIPTION

A. General:
   1. The intent of this Specification is that all process piping systems shown on the PLANS be provided with pipe hangers and supports.
   2. CONTRACTOR is responsible for the design of the pipe support system. Reference Paragraph 1.07 B.

B. Design Requirements:
   1. Select and design within the specified spans and component requirements.
   2. The absence of pipe supports and details on the PLANS does not relieve the CONTRACTOR of responsibility for sizing and providing supports as required for the process piping shown on the PLANS.
   3. Meet requirements of MSS SP-58.
   4. Structural Design Criteria:
      a. Dead loads imposed by the weight of the pipes and appurtenances filled with water plus any insulation.
      b. Safety factor: Minimum of 5.
   5. Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor the supports to withstand the shear and pullout loads imposed by loading and spacing on each support.
   6. Framing Support System:
      a. Beams: Size such that beam stress does not exceed 25,000 psi and maximum deflection does not exceed 1/240 of the span.
      b. Column Members: Size in accordance with the manufacturer's recommended method.
      c. Support Loads: Determine based on pipes filled with water.
      d. Electrical Conduit Support: Include provision for electrical conduit routing in the design of the framing support system.
   7. The load rating for universal concrete inserts is not to be less than that of the hanger rods they support.

1.06 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, "Submittals" and Section 01730, "Operation and Maintenance Data."
   1. Product Data: Submit product data characteristics, performance, limitations, and recommended uses.
   2. Manufacturer's Installation Instructions.
   3. Manufacturer's Compliance Certificate.
   4. Furnish drawings of all pipe supports, hangers, anchors, and guides. Drawings of each piping system locating each support, hanger, guide, or anchor. Installation details, materials, loads or forces and deflection of all hangers and supports.

5. Engineered hanger assemblies are to be detailed on 8½″ × 11″ sheets. Each sketch to include a location plan showing the location of the hanger in relation to columns and equipment.
6. Manufacturer's catalog data, literature, and engineering data for all hangers and supports.
7. Certificate of conformance as required in Paragraph 1.07-Quality Assurance.

1.07 QUALITY ASSURANCE

A. Obtain each type of pipe hanger or support from no more than one manufacturer.

B. Piping Support Design:
1. The design, computations, and detail drawings for the pipe supports and hangers are to be prepared by or under the direct supervision of a Professional Engineer registered in the State of Texas.
2. Piping support design engineer is to be ordinarily engaged in the design and analysis of pipe support systems.
3. The design engineer is to develop a detailed support system specific to the piping material, pipe joints, valves, piping appurtenances, system pressures and temperatures proposed as part of the Work.
4. Provide certificate signed and sealed by same engineer stating that the pipe support computations and pipe support drawings are in conformance with the design criteria.

1.08 DELIVERY, STORAGE AND HANDLING

A. Loose parts are to be shipped in crates that are clearly marked as to contents. Ship fabricated supports in largest sections permissible by carrier regulations.

B. All materials are to be inspected for size, quality and quantity upon delivery to site.

C. Store in a covered dry location until time of installation.

1.09 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 GENERAL

A. Code Compliance: All piping systems and pipe connections to equipment to be properly supported, to prevent undue deflection, vibration, and stresses on piping, equipment, and structures. All supports and parts thereof to conform to the requirements of ASME B31.1, except as supplemented or modified by these Specifications.

B. Structural Members: Wherever possible, pipes are to be attached to structural members. Where it is necessary to frame structural members between existing members, such supplementary members to be provided by the CONTRACTOR at no additional cost to the OWNER. All supplementary members to be in accordance with the requirements of the building code and the American Institute of Steel Construction.

C. Support Spacing: Supports for piping with the longitudinal axis in approximately a horizontal position to be spaced to prevent excessive sag, bending and shear stresses in the piping, with special consideration given where components, such as flanges and valves, impose concentrated loads. Where calculations are not made or more stringent requirements from pipe manufacturers prevail, suggested maximum spacing of supports are given in the tables below. Vertical supports to be spaced to prevent the pipe from being overstressed from the combination of all loading effects.

D. Pipe Hangers: Pipe hangers to be capable of supporting the pipe in all conditions of operation, allow for free expansion and contraction of the piping, and prevent excessive

stress on equipment. All hangers to have a means of vertical adjustment after erection. Hangers to be designed so that they cannot become disengaged by any movement of the supported pipe. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves, to include hydraulic shock suppressors.

E. Hangers Subject to Horizontal Movements: At hanger locations where lateral or axial movement is anticipated, suitable linkage to be provided to permit such movement. Where horizontal pipe movement is greater than ½-inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold to the hot position of the pipe, the hanger rod and structural attachment to be offset in such a manner that the rod is vertical in the hot position.

F. Spring-Type Hangers: Spring-type pipe hangers to be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping. All spring-type hangers to be sized to the manufacturer's printed recommendations and the loading conditions encountered. Variable spring supports to be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate at all times the compression of the spring. The support to be designed for a maximum variation in supporting effort of 25 percent for the total travel resulting from thermal movement.

G. Thermal Expansion: Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or joints to be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints. Design to allow the piping to expand and contract freely in directions away from the anchored points and to be structurally suitable to withstand all loads imposed.

H. Heat Transmission: Supports, hangers, anchors, and guides to be so designed and insulated, that excessive heat will not be transmitted to the structure or to other equipment.

I. Riser Supports: Where practical, risers to be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

J. Freestanding Piping: Free-standing pipe connections to equipment, like chemical feeders, pumps, etc., to be firmly attached to fabricated frames made of angles, channels, or I-beams anchored to the structure. Exterior, free-standing overhead piping to be supported on fabricated pipe stands, consisting of pipe columns anchored to concrete footings, with horizontal, welded steel angles and U-bolts or clamps, securing the pipes.

K. Submerged Supports: All submerged or partially submerged piping to be supported with hangers, brackets, clips, or fabricated supports and anchors of Type 316 stainless steel, unless otherwise shown.

L. Point Loads: Any meters, valves, heavy equipment, and other point loads on PVC, fiberglass, and other plastic pipes, to be supported on both sides, according to manufacturer's recommendations to avoid undue pipe stresses and failures. To avoid point loads, all supports on plastic and fiberglass piping to be equipped with extra wide pipe saddles or galvanized steel shields.

M. Noise Reduction: To reduce transmission of noise in piping systems, all copper tubes in buildings and structures to be wrapped with a 2-inch wide strip of rubber fabric or similar, suitable material, at each pipe support, bracket, clip, or hanger.

N. Anchors: As specified in Section 05120.

2.02 MATERIALS

A. General:

1. Materials for Supports and Hangers: Materials for pipe supports and hangers to be as specified or shown on PLANS. When PLANS lack such information, hangers, supports, and anchor bolts to be manufactured/fabricated of the following materials:
    a. Type 304 or 316 stainless steel for locations as follows:
        1) Submerged.
        2) Less than 1 foot above the liquid surface.
        3) Below top of channel walls.
        4) Under covers or slabs of channels and tanks.
        5) Other damp locations.
        6) Field welding and fabrication of supports is prohibited.
        7) Shop-fabricated supports:
            a) Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
            b) At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A 380 or A 967.
    b. Passivation treatments using citric acid are not allowed. Hot dipped galvanized for all other locations. Hot-dip galvanize pipe supports after fabrication.
    c. Plastic, aluminum, FRP, and other miscellaneous materials: Use where specifically indicated on the Drawings.
2. Fabricate pipe supports of the correct material to the general configuration indicated by catalogs when specified items are not available in specified material.
3. Manufacturer's catalog/figure numbers are typical of the types and quality of pipe supports and hangers to be provided.
4. Special support and hanger details are shown to cover typical locations where standard catalog supports are inapplicable.
5. Furnish fabricated and standard hangers and supports complete with necessary inserts, bolts, nuts, rods, washers, and other accessories.
6. Run piping in groups and parallel to building lines where practical. Provide minimum clearance of 1-inch between pipe and other Work.
7. Install hangers and supports at all locations where piping changes direction.
8. All hangers and supports to be capable of adjustment after placement of piping.
9. Each type of hanger or support is to be the product of one manufacturer. Types of hangers to be kept to a minimum.
10. Vertical Piping to be supported at each floor and between floors by stays or braces designed to prevent rattling and vibration.
11. Chain, wire, strap, or perforated bar hangers are not acceptable.
12. Piping may not be suspended from piping above it.
13. Provide thrust supports designed to be field adjusted and capable of restraining the loads generated by pipe movement due to expansion and contraction.
14. Provide intermediate or guide supports at intervals not exceeding 20 feet.
15. Guide supports to cradle the bottom 90 degrees of the pipe, and the bearing surface is to be contoured to fit the pipe.
16. Unless noted otherwise on PLANS, do not clamp piping to building surfaces; use offset supports.
17. Where concrete supports are shown, apply two layers of 15-pound building felt under the pipe in contact with the concrete. Neatly trim felt around support.
18. Pitch piping to drain when shown on PLANS.
19. Provide lateral and longitudinal support as required to resist lateral loading such as wind.
20. Dissimilar Metals:
    a. Thin walled stainless steel piping is to be isolated from carbon steel by using stainless steel or fiberglass hangers or supports.
    b. Prevent contact between dissimilar metals by using copper-plated, rubber or vinyl coated or stainless steel hangers or supports.

2.03 PIPE SUPPORTS

A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 133.
         2) Nibco-Tolco, Figure 103.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 140.
         2) Bergen-Power, Figure 133.
         3) Cooper B-Line Systems, Inc., Figure B3205.

B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 94.
         2) FM Stainless Fasteners.
      b. For steel and ductile iron piping:
         1) Anvil International, Figure 146.
         2) Bergen-Power, Figure 94.

C. Eye bolts:
   1. For stainless steel piping:
      a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
   2. For all other piping, unless indicated on the Drawings:
      a. Welded and rated equal to full load capacity of rod.

D. Welded eyebolt rod:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 101.
         2) FM Stainless Fasteners.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 278.
         2) Bergen-Power, Figure 93.
         3) Cooper B-Line Systems, Inc., Figure B3210.

E. Adjustable ring hangers: MSS SP-69, Type 7 or Type 9 (system dependent):
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1C.I.
         2) Bergen-Power, Figure 100SS.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 97.
         2) Cooper B-Line Systems, Inc., Figure B3172.

F. Adjustable clevis hangers: MSS SP-69, Type 1:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc, Figure B3100 or B3102.
         2) FM Stainless Fasteners, Figure 60.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 260 or Figure 590.
         2) Bergen-Power, Figure100.
         3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

G. Adjustable clevis hangers for insulated pipe: Oversize:
   1. Manufacturers: One of the following or equal:

a. For stainless steel piping:
1) Nibco-Tolco, Figure 1A.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 300.
2) Bergen-Power, Figure 100EL.
3) Cooper B-Line Systems, Inc. Figure B3108.

H. Brackets: MSS SP-69, Type 32 with back plate; rated for 1,500 pounds:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 30M.
2) Cooper B-Line Systems, Inc., Figure B3066.
3) FM Stainless Fasteners, Figure 98.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 195.
2) Cooper B-Line Systems, Inc., Figure B3066.

I. Brackets, heavy duty: MSS SP-69, Type 33 with back plate; rated for 3,000 pounds:
1. Manufacturers: One of following or equal:
a. Anvil International, Figure 199.
b. Cooper B-Line Systems, Inc., Figure B3067.

J. Standard U-bolt: MSS SP-69, Type 24:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 110.
2) Cooper B-Line Systems, Inc., Figure B3188.
3) FM Stainless Fasteners, Figure 37.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 137.
2) Bergen-Power, Figure 283.
3) Cooper B-Line Systems, Inc., Figure B3188.

K. Riser clamps: MSS SP-69, Type 8:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Cooper B-Line Systems, Inc., Figure B3373.
2) FM Stainless Fasteners, Figure 61.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 261.
2) Bergen-Power, Figure 126.
3) Cooper B-Line Systems, Inc., Figure B3373.

L. Pipe clamps: MSS SP-69, Type 4:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 4.
2) Cooper B-Line Systems, Inc., Figure 3140.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 212.
2) Bergen-Power, Figure 175.
3) Cooper B-Line Systems, Inc., Figure B3140.

M. Adjustable offset pipe clamp:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 4.
2) Cooper B-Line Systems, Inc., Figure B3149.
3) FM Stainless Fasteners, Figure 63.

b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 100.
2) Cooper B-Line Systems, Inc., Figure B3149.

N. Offset pipe clamp:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 8.
2) Cooper B-Line Systems, Inc., Figure 3148.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 103.
2) Cooper B-Line Systems, Inc., Figure B3148.

O. Floor stand or stanchion saddles: MSS SP-69, Type 37. Provided with U-bolt hold down yokes:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 318.
2) FM Stainless Fasteners, Figure 59.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 259.
2) Bergen-Power, Figure 125.
3) Cooper B-Line Systems, Inc., Figure B3090.

P. Spring hangers:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Bergen-Power, Figure 920.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure B-268, Type G.
2) Bergen-Power, Figure 920.

Q. One hole pipe clamps:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Not used.
b. For all other piping:
1) Anvil International, Figure 126.
2) Carpenter & Paterson, Figure 237S.

R. Welded beam attachment: MSS SP-69, Type 22:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 304.
2) Cooper B-Line Systems, Inc., Figure 3083.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 66.
2) Bergen-Power, Figure 113A or 113B.
3) Cooper B-Line Systems, Inc., Figure B3083.

S. Heavy pipe clamp: MSS SP-69, Type 4:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 4H.
b. For all other piping, unless called out otherwise on the Drawings:
1) Anvil International, Figure 216.
2) Bergen-Power, Figure 298.

T. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
1. Manufacturers: One of the following or equal:

a. For stainless steel piping:
   1) Nibco-Tolco, Figure 426.
b. For all other piping, unless indicated on the Drawings:
   1) Anvil International, Figure 257, Type 3.
   2) Cooper B-Line Systems, Inc., Figure B3893.

PART 3 EXECUTION

3.01 GENERAL

A. General: All pipe supports, hangers, brackets, anchors, guides, and inserts to be fabricated and installed in accordance with the manufacturer's printed instructions and ANSI/ASME B31.1. All concrete inserts for pipe hangers and supports to be coordinated with the formwork.

B. Appearance: Pipe supports and hangers to be positioned in such a way as to produce an orderly, neat piping system. All hanger rods to be vertical, without offsets. Hangers to be adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, without interference with other work.

C. All supports to be securely fastened.

3.02 PREPARATION

A. Locate hangers, supports and accessories to support piping, valves and at all concentrated loads.

B. Locate hangers, supports and accessories within maximum span lengths specified to support continuous pipeline runs.

C. Locate hangers and supports to prevent vibration or swaying and to provide for expansion and contraction.

D. Install items to be embedded before concrete placement.

E. Fasten embedded items securely to prevent movement during concrete placement.

F. Install hanger and support units on piping systems as recommended by manufacturer.

G. Adjust hangers and supports and place grout for concrete supports to bring pipelines to specified elevations.

3.03 INSTALLATION

A. Properly support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the PLANS.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use powder-actuated fasteners for securing metallic conduit larger than 1 inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods and secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the PLANS.

I. Use adjustable ring hangers or adjustable clevis hangers, for 4 inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
1. For stainless steel piping, use stainless steel U-bolts.
2. For all other piping, use galvanized U-bolts.

L. Support spacing:
1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
4. Support tubing, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4 inch between supports.
5. For welded, fabricated steel pipe sizes not used in this table, the support spacing to be designed so that the stress on the pipe does not exceed 5,000 psi. This may be calculated by using the formula:

$$L = \frac{7{,}500tD}{32t + D}$$

where: t = Thickness, in.
D = Diameter, in.
L = Safe Span, ft.

M. Maximum deflection of pipe to be limited to 1/360th of the span.
1.

N. Install supports at:
1. Horizontal bends.
2. Both sides of flexible pipe connections.
3. Base of risers.
4. Floor penetrations.
5. Connections to pumps, blowers, and other equipment.
6. Valves and appurtenances.

O. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

P. Anchor plastic pipe between expansion loops and direction changes to allow axial movement through anchors.

Q. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.

R. Support base fittings with metal supports or when indicated on the PLANS support on concrete piers.

S. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

T. Support plumbing drainage and vents in accordance with applicable local plumbing code.

U. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

V. Where pipe is insulated, install over-sized supports and hangers.

W. Install insulation shield in accordance with MSS SP-69, Type 40. Shield shall be galvanized steel unless otherwise specified or indicated on the PLANS.

X. Install riser clamps at floor penetrations and where indicated on the PLANS.

Y. Coat support system components as specified in Section 09902.

3.04 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15062

DUCTILE IRON PIPE AND CAST IRON AND DUCTILE IRON FITTINGS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes furnishing ductile iron piping three inches and larger for buried and exposed systems. Soil pipe and fittings are specified in other Specification Sections.

1.02 RELATED REQUIREMENTS

A. Soil pipe and fittings not under this Specification Section.

B. PLANS show pipe class, thickness class, type joints, and service pressure.

C. 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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.2.1	Square and Hex Bolts and Screws (Inch Series)
ANSI B18.2.2	Square and Hex Nuts (Inch Series)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

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

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105	Polyethylene Encasement for Ductile Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings, 3-inch Through 48-inch (75 mm Through 1200 mm), for Water and Other Liquids
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron Pipe with Threaded Flanges
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast, for Water

1.04 - 1.05 (NOT USED)

1.06 SUBMITTALS

A. Furnish in accordance with Specification Section 01300, “Submittals”. In addition to the items specified in Section 01300 “Submittals”, furnish the following:

1. Detailed installation drawings for piping.

2. Manufacturer’s descriptive literature for mechanical couplings, mechanical flange adapters, and restrained flange adapters.

3. Certified test reports for threaded-on flanged pipe in for shop testing required.

4. Certification per Paragraph 1.07.

B. The City of Austin Water and Wastewater Utility Standard Products Lists (SPL) are considered to form a part of these Specifications. Contractors may, when appropriate, elect to use products from the SPL; however, submittal to the Engineer/Architect (E/A) is still required. If the Contractor elects to use any materials from these lists, each product shall be completely and clearly identified by its corresponding SPL number when making the product submittal. This will expedite the review process in which the E/A, and, if necessary, the Water and Wastewater Utility Standard Products Committee, decide whether the products meet the Contract requirements and the specific use foreseen by the E/A in the design of this engineered Project. The SPL’s should not be interpreted as being a pre-approved list of products necessarily meeting the requirements for a given construction Project. Items contained in the SPL cannot be substituted for items shown on the Drawings, or called for in the specifications, or specified in the Bidding Requirements, Contract Forms and Conditions of Contract, unless approved by the E/A in conjunction with the Water and Wastewater Utility Standard Products Committee. The Standard Product List current at the time of plan approval will govern.

1.07 QUALITY ASSURANCE

A. Certification:

1. Pipe used in domestic water distribution systems to have Underwriters’ label and be acceptable to local and state authorities without penalty.

2. Furnish sworn statement that inspection and all tests have been made and meet the requirements of AWWA C151.

1.08 DELIVERY, STORAGE AND HANDLING

A. Shipping:

1. Piping with flanged ends to be protected with blank wooden or fiberboard flange protectors. Backing flanges are to be secured to the pipe ends.

2. Pipe spools to loaded and blocked and lagged as necessary to ensure protection against damage during shipping.

3. Loose parts (couplings, nuts and bolts, gaskets, etc.) are to be shipped in crates that are clearly marked as to contents.

B. Handling and Unloading:

1. Unload and handle piping in accordance with pipe manufacturer’s instructions.

2. Transfer of pipe to be accomplished utilizing nylon straps or steel cables.

3. Exercise extra care when handling flanged pieces due to the additional loads imparted by the flanges. (Insert blocking or other means to support the flanges independently of the pipe to prevent the weight of the flange from distorting the pipe.)

4. 4. Maintain plugs and flange protectors in openings to protect the pipe.

5. Do not dump piping off of transport vehicle. Any damaged, chipped, or cracked fittings or pipe to be replaced at CONTRACTOR's expense.

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.

3. Store at job site on 4″ × 4″ blocking at 6′ spacing. Piping may be stacked a maximum of three rows high as long as 4″ high spacers are used on 6′ centers.

4. Keep interior of piping free of all foreign matter.

1.09 - 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 **MANUFACTURER(S)**

A. Pipe:

1. American Cast Iron Pipe Co.

2. McWane Incorporated

3. U.S. Pipe & Foundry

B. Fittings:

1. American Cast Iron Pipe Co.

2. McWane Incorporated

3. U.S. Pipe & Foundry Co.

4. Tyler Pipe

5. Griffin Pipe

2.02 **MATERIALS AND/OR EQUIPMENT**

A. A. General: Fabrication dimensions and accuracy of fabrication are responsibility of CONTRACTOR.

B. Pipe:

1. Ductile Iron: Per AWWA C151.

2. Thickness Class:

   a. Aboveground Lines: As shown on PLANS and minimum for flanged pipe per AWWA C115.

   b. Underground Lines: As shown on PLANS, but not less than that indicated within AWWA C150 for internal pressure and depth shown on PLANS.

C. Fittings, Flanges, and Joint Material:

1. Fittings: Per AWWA C110 and C111.

2. Threaded-On Flanges: Per AWWA C115. Use ductile flanges on ductile fittings and cast iron flanges on cast iron fittings.

3. Nonflanged Joint Material

   a. Rubber Gaskets for Water and Sewage Service: Per AWWA C111.

   b. Rubber Gaskets for Diffused Air Systems (10 psi and 210°F Service): EPDM.

D. Restrained Joints:

1. Restrained Joint Pipe:

   a. Pipes 16" and less: Joints to be restrained by Mega-Lug, by EBAA Iron, Inc. or equal by Ford Meter Box Co. Provide Mega-Lug Series 1100 and mechanical joint pipe and fittings, or equal by Ford Meter Box Co. Provide Mega-Lug Series 1700, or equal by Ford Meter Box Co. for push on joints.

   b. Pipes greater than 16": Provide one of the following joint restraint systems:

      (1) Flex-ring or Lock ring by American Cast Iron Pipe Co.

      (2) TR Flex by U.S. Pipe Co.

      (3) Super-Lock by Clow Corp

      (4) Approved equal; locking gaskets not allowed.

E. Gaskets:

1. For water and sewage, use rubber gasket conforming to the Appendix in AWWA C115.

2. For air service, use 1/8-inch full-face EPDM gaskets, factory cut and conforming to AWWA C111.

F. Bolts and Nuts:

1. Aboveground:

   a. Hex head bolts and nuts:

      (1) Bolts per ANSI B18.2.1.

(2) Nuts per ANSI B18.2.2.

b. Number, size, and length per Table 15.2 of AWWA C115.

c. Material: Low carbon steel per ASTM A307.

d. Use studs with nuts on each end for pipe sizes 54″ and larger.

2. Underground:

a. Tee-head bolts and hexagonal nuts per AWWA C111.

b. Number, size, and length per Table 11.1 of AWWA C111.

c. Material: Low alloy steel or high strength cast iron in accordance with AWWA C111.

G. G. Exterior Coating:

1. Buried Pipe and Fittings: Bituminous coated, not less than 1 mil thick.

2. Exposed Pipe and Fittings: Reference Section 09902 “Painting and Protective Coatings” for coating requirements. Bituminous coated pipe and fittings will not be allowed.

H. Interior Lining (pipe and fittings):

1. Air Service: Unlined.

2. Water Service: Cement mortar lined per AWWA C104/A21.4.

3. Sewage Service:

a. Interior lining for ductile iron sewer pipe to conform to manufacturer’s recommendations.

b. Minimum lining thickness to be 40 mils regardless of material recommended.

c. Acceptable lining materials are:

(1) “Corropipe II Wasteliner” by Madison Chemical Industries.

(2) “Polythane” by Madison Chemical Industries.

(3) “Protecto 401” ceramic epoxy by Vulcan Group.

(4) “SP-2000W” by Superior Environmental Products.

(5) “SewPerCoat” by La Farge Calcium Aluminates.

4. Scum and Sludge Service: Glass Lining

a. Glass Lining: Vitreous material that is smooth, continuous and formulated to prevent the adherence of grease, scum and crystalline metal salt deposits in sludge, scum and related process piping systems in wastewater and sewage treatment systems.

b. Provide lining consisting of two coats, separately applied and separately fired at a maturing temperature of approximately 1400 degrees F creating a molecular bond with the base metal and a total minimum lining thickness of 8-10 mils.

c. Lining minimum hardness: 5-6 on the MOHS scale.

d. Provide lining capable of withstanding an instantaneous thermal shock of 350 degrees F differential without crazing, blistering or spalling.

e. Provide lining capable of withstanding a strain of 0.001 inch/inch, the yield point of the base metal, without damage to the glass lining.

f. Provide lining resistant to corrosion of between PH-3 to 10.

g. Testing Procedure: In accordance with industry standards "MP-9.2 .1-Industry Continuity Test Procedures-Porcelain Enamel (Glass) Lined Pipe and Fittings".

(1) Acceptance Criteria:

Pipe Diameter	Maximum Pinholes/Fitting	Maximum Pinholes/ 20 Foot Pipe Length
8-inches and Smaller	3 to 5	10 to 12
10 to 18-inches	5 to 8	18 to 20
20-inches and Larger	8 to 10	25 to 28

h. The above criteria represents non-visible pinholes detectable by low voltage spark test only. Any pinholes that are visible to the naked eye and expose the base metal are not acceptable.

i. Factory test all pipe and fittings, with certified copies of the test results accompanying each shipment.

j. Provide documents identifying each individual item by mark number and description, the Quality Control Sequence Number, date tested, inspector, and the number of pinholes detected per item.

k. Fabricators:

(1) Custom-Fab.

I. Encasement: Polyethylene encasement in accordance with AWWA C105.

J. Mechanical Couplings: Dresser Style 38, long sleeve unless shown otherwise; equivalent by Smith-Blair or Baker. Harness when required for thrust restraint.

K. Flanged Coupling Adapters:

1. Exterior piping: Dresser Style 127 (2″-12″), Dresser Style 128 (14″-96″), equivalent by Smith Blair or equal.

2. Interior piping: Baker Dismantling Joint with harness tie bolts (54"-60"), Dresser Style 127 (2″-12″), Dresser Style 128 (14″-48″), equivalent by Smith Blair or equal.

L. Restrained Flanged Coupling Adapters:

1. Exterior piping: EBAA Iron Series 2100 or equal by Ford Meter Box Co.

2. Interior piping: Baker Dismantling Joint with harness tie bolts (54”-60”), EBAA Iron Series 2100 or equal by Ford Meter Box Co. (all other pipe sizes).

M. Wall Pipes: Unless otherwise shown on PLANS, wall pipes to be cast or ductile iron with an intermediate wall collar. End connections to be as shown on PLANS.

2.03 FABRICATION

A. Flanged Pipe

1. Threaded-On Flanged Pipe:

2. Shop thread, machine tight, and face in machine shop equipped for this type work and conforming to the requirements of AWWA C115.

2.04 SOURCE QUALITY CONTROL

A. Threaded-On Flanged Pipe: Shop test, hydrostatically, each flanged pipe piece at 150 psig.

PART 3 EXECUTION

3.01 - 3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Installation: Per applicable Specification Section.

3.04 - 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15063

INSTALLATION OF DUCTILE IRON PLANT PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes all work necessary to install ductile iron plant piping as specified herein and as shown on the PLANS.

1.02 RELATED REQUIREMENTS

A. PLANS show sizes, elevations, arrangements, special encasement, and specials.

B. 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.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems

1.04 - 1.10 (NOT USED)

1.11 SCHEDULING

A. Slab, Floor, Wall and Roof Penetrations:

1. Order wall pipes and sleeves sufficiently early to ensure they are available for placement in concrete forms.

2. Verify size and location of building and structure penetrations before forming and placing concrete.

PART 2 PRODUCTS

2.01 PIPE MARKING TAPE

A. Material: Inert polyethylene plastic impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.

B. Thickness: Minimum 4 mils.

C. Width: 12 inches.

D. Color: In accordance with APWA Uniform Color Code for Temporary Marking of Underground Utility Locations.

E. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.

F. Manufacturers and Models:

1. Reef Industries, Terra Tape.

2. Allen, Markline.

PART 3 EXECUTION

3.01 GENERAL

A. Examination - Verification of Existing Pipe and Penetrations:

1. Prior to ordering materials, expose all existing pipes which are to be connected to new pipelines.

2. Verify the size, material, joint types, elevation, horizontal location, and pipe service of existing pipes.

3. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings before installing connecting pipes.

B. Preparation - New Pipe and Fittings:

1. Inspect before exposed pipe or fitting is installed or buried pipe or fitting is lowered into the trench.

2. Clean ends of pipe thoroughly, remove foreign matter and dirt from inside of pipe, and keep clean during and after installation.

C. Coatings:

1. Install exterior protective coating on all pipes as specified in other Specification Sections.

2. Color-code and label non-submerged piping per applicable Specification Section.

3. Damaged Internal Coatings: Repair damaged areas in field with material equal to original coating.

D. Valves: Locate where shown on the PLANS and install per applicable Specification Section.

E. Vents and Drains: Vent the high points and drain the low points of pipelines only where shown on the PLANS.

F. Wall Pipes: Provide wall pipes with thrust collar for all penetrations through concrete walls, floors, slabs, or roofs that are to be watertight unless otherwise specified or shown on PLANS. Coat buried fasteners on wall pipes per applicable Specification Section.

3.02 JOINTING PIPE

A. Bell and Spigot Boltless, Gasketed, Joints:

1. Preparation of Pipe Ends: Remove from bell and spigot ends all lumps, blisters, excess coal-tar coating, oil, grease, and foreign matter, then wire brush and wipe clean and dry before laying pipe.

2. Installation of Ring Gasket: Wipe gasket seat in socket with clean dry cloth. Place gasket with large end entering first. Spring gasket into seat in bell so that groove fits over head in seat. Apply thin film of lubricant to inside surface of gasket. Lubricant to be furnished by pipe manufacturer to ensure compatibility with any special coatings.

3. Setting Spigot: Align spigot with bell and start into bell so that it contacts gasket. Apply lubricant to engaging surface of spigot if necessary. Pipe 6″ and smaller may be driven with a bar lever on end of pipe. For larger pipe, use only approved ratchet-type jacking tool to pull pipe “home”.

B. Mechanical Joints:

1. Wash socket and plain end with soapy water, then slip gland and gasket over plain end. Face small side of gasket and lip of gland to bell.

2. Paint gasket with soapy water.

3. Push gasket into position, being sure it is evenly seated in socket.

4. Slide gland into position, insert bolts, and run nuts up finger-tight.

5. Tighten bolts to uniform tightness with ratchet wrench. First tighten bottom bolt, then top, and on around in sequence of 180 apart.

C. Flanged:

1. Wire brush flange and clean inside of pipe before placing gasket.

2. Setting Gasket: If non-graphite gaskets are used, apply graphite and water solution to gasket before placing on flange.

3. Tightening Bolts: After initial alignment, place flange bolts with all heads in the same direction. Tighten flange bolts, each in turn, at a uniform rate around joint until all are tight.

D. Restrained Flange Adapter Joints:

1. Use only when shown on PLANS or authorized by ENGINEER.

2. Install in strict accordance with manufacturers printed instructions and as specified above.

E. Special Jointing Procedures:

1. New Piping that Connects to Existing Piping:

a. General: Any connection to existing piping will require, at a minimum, new gaskets and new nuts and bolts.

b. Preparation:

(1) Excavate and expose piping for underground connections. Install temporary supports for aboveground piping.

(2) Inventory materials to verify that all fittings, gaskets, nuts, bolts, etc. are on hand to complete connection.

(3) Coordinate isolation operations in conjunction with plant or utility personnel. Do not close valves or stop equipment.

(4) Isolate and drain existing piping.

(a) If existing line is a wastewater line, direct drainage to sanitary sewer.

(b) If existing line is a water line, then direct drainage to nearest storm sewer or swale.

c. Underground: Remove any thrust blocking that may exist after the pipe has been removed from service.

(1) Connection to Plug or Existing Fitting: Remove existing plug or fitting. Make new connection using mechanical joint or bell and spigot jointing procedure above, as applicable. Install thrust restraint as applicable.

(2) Connection to Pipe Barrel: Cut existing pipe using a guillotine saw, milling cutter, or abrasive saw. Square pipe ends and bevel pipe. Seal exposed metal with coal tar epoxy. Insert new fitting(s) as shown on plans. Complete connection using a solid sleeve, cutting-in sleeve, or other coupling approved by ENGINEER. Install thrust restraint as applicable.

d. Above Ground:

(1) Connection to Existing Flange: Remove blind flange or existing fitting. Face existing flange to obtain a uniform sealing surface. Install new piping or fittings as shown on the PLANS using the flanged jointing procedure above with a new gasket and new nuts and bolts.

(2) Cut existing pipe using a guillotine saw, milling cutter, or abrasive saw. Square pipe ends and bevel pipe. Seal exposed metal with coal tar epoxy. Insert new fittings as shown on PLANS and complete joint with a restrained flanged coupling adapter or a coupling with thrust restraint. Install piping support under new connection.

2. Pipe Connections at the Boundary between Two Construction Contracts: Make connection per detail shown on PLANS.

3. Connections to Other Pipe Materials: Make connection using coupling approved by ENGINEER with appropriate transition gaskets.

3.03 UNDERGROUND INSTALLATION

A. General:

1. Lay pipe and fittings in conformance with manufacturer's instructions and alignment and elevations shown.

2. Provide all special tools and devices, such as special jacks, chokers, and similar items required for proper installation.

3. Use pipe joints lubricant as specified; no substitutions will be permitted.

4. Do not lay pipe in water or when, in the opinion of the ENGINEER, trench conditions are unsuitable.

5. Prevent uplift and floating of pipe prior to backfilling. Prevent foreign material from entering pipe at all times during placement.

B. Excavation and Preparation of Trench:

1. Geometry: Maximum width per detail on PLANS.

2. Brace trench and drain as necessary to accomplish work safely and efficiently as defined by CONTRACTOR's Trench Safety Plan.

3. Dewater trench as necessary by pumping, well pointing, or other means to keep trench clear of water. Deliver discharge from pumps to natural drainage ditches or to drains. Attain discharge permit if required at no additional cost to OWNER.

4. Grade trench bottom to line and grade to which pipe is to be laid, with proper allowance for pipe thickness and pipe base material.

5. Remove hard spots that would prevent a uniform thickness of base or uniform pressure on the pipe barrel.

6. Place pipe base material to proper grade for full width and length of trench. Minimum depth of pipe base below barrel of pipe to be as shown on Detail on PLANS.

7. Excavate bell holes at each joint to permit proper assembly and visual feeler gauge inspection of the entire joint.

8. If trench has been excavated below the required depth for pipe base placement without approval by ENGINEER, fill excess depth to proper subgrade with pipe base specified herein, at the CONTRACTOR's sole expense.

C. Alignment and Grade:

1. To Grade: As shown with joints centered and spigots home.

2. Not to Grade: Minimum depth of cover 36-inches under finished grade; 18-inches under flow lines of drainage ditches; depth of cover at other locations as shown on PLANS.

3. Correcting Faulty Grade: Correct any part of trench excavated below grade with approved, thoroughly compacted material.

4. Do not deviate more than 1 inch from line or ¼-inch from grade for gravity piping.

5. Measure for grade at the pipe invert, not at the top of the pipe.

6. Before laying each section of the pipe, check the grade with a straightedge and correct any irregularities found.

D. Pipe Handling and Laying:

1. Care: Load and unload by use of approved hoists, skids, or other approved means to avoid damage. Keep interior of pipe free of foreign matter.

2. Inspection: Before lowering pipe into trench, inspect pipe for defects. Replace defective joints, fittings, pipe, or coatings.

3. Apply 8-mil polyethylene encasement in accordance with AWWA C105 to all cast iron and ductile iron piping, including fittings and valves.

4. Laying:

    a. Lay pipe upgrade with bell ends facing direction of laying.

    b. After a section of pipe has been lowered into the prepared trench, clean the end of the pipe to be joined, the inside of the joint, and the rubber ring immediately before joining the pipe.

    c. Do not block under pipe.

    d. Do not lay pipe in water.

    e. Lay pipe only when impending weather conditions will not endanger quality of workmanship or materials.

    f. Check gasket position with feeler gauge furnished by the pipe manufacturer to assure proper seating. Use feeler gauge of proper size, type and shape during installation for each type of pipe furnished.

5. Close and block the open end of the last laid section of pipe to prevent entry of foreign material or creep of the gasketed joints, at all times when laying operations are not in progress, at the close of the day's work, or when the workers are absent from the job.

6. Deflection of Joints:

    a. PLANS indicate minor changes in slope and direction without corresponding fittings. Accommodate changes by deflecting joints. Standard bends may be required to conform to manufacturer's allowable deflection and the following requirements.

    b. Deflect pipe at joints for pipelines using unsymmetrical closure of spigot into bell.

    c. Maximum Deflection: 90 percent of maximum deflection recommended by pipe manufacturer for restrained joint pipe, 50 percent for all other joints.

    d. Conform to lines and grades on PLANS. Misalignment at point of intersection (PI) of up to 1 foot is allowable provide that line and grade is re-established within 60 feet of PI.

    e. Record deflections and/or standard fittings on As-Built drawings.

    f. Use one of the following methods if joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment:

        (1) Shorter pipe lengths.

        (2) Standard bends.

7. After the joint has been made, check pipe for alignment and grade.

8. Valve Boxes and Valves: Set valves and boxes plumb and centered. Provide firm support by tamping selected material as directed. Set top of boxes at finished grade unless directed otherwise.

E. Backfill in the Pipe Zone (Unless Otherwise Noted on PLANS):

1. The pipe zone includes the full width of the excavated trench from the bottom of the trench to a level 12 inches above the top outside surface of the pipe barrel.

2. Deposit select backfill material in the trench simultaneously on both sides of pipe for the full width of trench in horizontal lifts not exceeding 8 inches uncompacted thickness.

   a. Work the material under the haunches of the pipe by slicing with a shovel.

   b. Moisten backfill and compact with tamping bars and/or mechanical compactors.

   c. Compact material at the sides of the pipe with vibratory plate compactors to 95 percent of the maximum density in accordance with ASTM D698.

   d. Do not operate the vibratory compactor over the top of the pipe until the full depth of the pipe zone material has been placed.

   e. Do not use impact type compactors for compaction until at least 4 feet of backfill is placed over the pipe.

3. Ensure that firm support is obtained in the area of the pipe zone from the invert to the spring line of the pipe, to prevent any lateral movement of the pipe during final backfilling of the pipe zone.

F. Backfilling and Cleanup (Unless Otherwise Noted on PLANS):

1. Time of Backfilling: Backfill as soon as practicable after completion of laying and jointing of pipe.

2. Backfill Procedure Above Pipe Zone: As shown on PLANS.

3. Rock and Rock Fragment Exclusion: Allow no rock or rock fragment in backfill for at least 1 foot above top of pipe and allow no stone larger than 8 inches in its greatest dimension in backfill.

4. Deficiency of Backfill: Supply any deficiency in quantity of materials for backfilling trenches or for filling depressions caused by settlement.

5. Removal of Excess Material: Remove from site, or use at site for fill as shown or approved.

G. Marking Tapes:

1. Install along centerline of all pipe on top of last lift of pipe zone material.

2. Use care to prevent damage to tape; repair any damage incurred.

H. Buried Pipe in Concrete Encasements or Concrete Bedding:

1. Pipe Joints: Do not encase in concrete unless specifically shown.

2. Pipe Coatings: Continuous through concrete encasements, thrust blocks, anchors, collars, etc., unless otherwise shown.

3.04 ABOVEGROUND INSTALLATION

A. General:

1. Clean each piece of piping to remove dirt, grease and other foreign matter.

2. Start with piping at “cast-in” wall fittings and work toward equipment. If “block-outs” are shown on PLANS, grout the same with high strength, non-shrink grout after piping is installed and aligned.

3. Run lines parallel to building lines.

4. DO NOT spring or force pipe into place or weaken structural portions of the building or structure.

5. Support piping as shown on PLANS and as required to distribute loads to structures, hangers, piping specials, and equipment so that excess stresses do not occur. Set all hangers and supports before flange bolts are tightened.

6. Align hangers supporting adjacent piping with equal support spans where possible.

7. Bring individual runs of piping to true grade and alignment by means of erection bolts and drift pins without forcing.

8. Bolt holes on flanges are to straddle vertical centerline of pipe.

9. Align and make up piping before grouting equipment to assure accurate alignment, then disconnect piping during grouting.

10. After equipment is grouted and grout set, make up piping, making use of flexible joints provided for that purpose, or as otherwise shown. Correct alignment as necessary to prevent stresses in flexible joints. Refer to flexible coupling manufacturer’s instructions for permissible limits of alignment.

11. Valve Orientation:

    a. As shown where valve handwheels are shown.

    b. Where valve handwheels are not shown, orient to permit easy access to the valve operator, and to avoid interferences.

12. Pipe Tap Connections:

    a. Taps to the pipe barrel are unacceptable.

    b. To Ductile Iron Piping: Connect only with service saddle or at a tapping boss of a fitting, valve body, or equipment casting.

B. Flexible Couplings, Flanged Coupling Adapters and Service Saddles

1. Thoroughly clean oil, scale, rust and dirt from the pipe to provide a clean seat for the gasket.

2. Wipe gaskets clean prior to installations.

3. Lubricate flexible couplings and flanged coupling adapter gaskets with soapy water or manufacturer's standard lubricant before installation on the pipe ends.

4. Install couplings, service saddles and anchor studs in accordance with manufacturer's instructions.

5. Tighten bolts progressively, drawing up bolts on opposite sides a little at a time until all bolts have a uniform tightness.

6. Use only torque-limiting wrenches to tighten bolts.

3.05 THRUST RESTRAINT

A. General:

1. Thrust restraint and ties for aboveground and underground piping is generally shown on the PLANS of the individual pipelines; however, their absence does not relieve the CONTRACTOR of the responsibility for providing them as required for a complete and operating system.

2. Provide thrust restraints to withstand test pressure specified.

B. Location:

1. At pipeline tees, plugs, caps, bends and other locations where unbalanced forces exist.

2. Provide thrust blocks and ties where required, whether or not shown.

3. Use thrust restraint for pressure pipelines at all bends, tees, points where reducers or changes in pipe diameter occur, fire hydrants or flushing valves, and all plugged openings. Provide restraint for an adequate length along pipeline on either side of a restrained joint to achieve a restrained system.

C. Thrust Ties: Install as detailed, or per joint restraint manufacturer's recommendations.

D. Restrained Joint Pipe and Fittings: Ductile iron restrained joint products are specified in Section 15062 "Ductile Iron Pipe and Fittings".

E. Concrete Thrust Blocking:

1. Use concrete having compressive strength not less than 1,500 pounds per square inch in each case.

2. Use all materials, including aggregate, cement, and water, and mix and place concrete in accordance with applicable concrete Specification Section.

3. Place blocking between undisturbed ground and the fitting to be anchored.

4. Place blocking so that pipe and fitting joints will be accessible for repair.

5. Size area of bearing on pipe and on ground in each instance as required for test pressure and bearing capacity of soil.

6. Provide concrete thrust blocking where shown on PLANS and as detailed on PLANS.

3.06 ENCASEMENT AND FOUNDATIONS

A. PLANS require encasement and fitting foundations at specific locations.

B. Encasement (Provide where shown on PLANS): Use 1,500 psi compressive strength concrete minimum. Provide minimum 6" encasement on all sides of pipe for pipes 16" and smaller. Provide 12" encasement on all sides of pipe greater than 16".

C. Fitting Foundations:

1. Provide where shown on PLANS and at all vertical bends when the adjoining vertically oriented pipe extends more than 6 feet above finished grade.

2. Use type K concrete for fitting foundations per Section 03301 "Concrete".

3. Provide bottom mat of #5 rebar, 9" on center each way, located 3" off bottom of concrete foundations.

4. Pipes 24" and less: Provide foundation that is 24" wider than pipe (12" on each side) and 12" in depth as measured from the bottom of the pipe.

5. Pipes greater than 24": Provide foundation that is 48" wider than pipe (24" on each side) and 24" in depth as measured from the bottom of the pipe.

6. Cradle the bottom 30 degrees of the pipe with the foundation. Isolate pipe from foundation with a layer of 30 pound roofing felt.

7. If foundation conflicts with other facilities, adjust shape accordingly to maintain 4" clearance.

3.07 REPAIR/RESTORATION

A. Restoration: Replace walks, drives, shrubbery, trees, fences, sod, and any like obstructions removed or disturbed, where such are to be retained as a part or feature of a completed project.

3.08 FIELD QUALITY CONTROL

A. General:

1. Hydrostatically test all piping systems installed at the test pressures shown on PLANS or specified elsewhere in the TECHNICAL SPECIFICATIONS.

2. All tests are to be witnessed and acceptable to the ENGINEER.

3. Test lines laid under structures or pavement prior to such construction.

B. Field-test all piping in accordance with Section 02687, "Testing of Installed Piping Systems".

C. Repairs: Repair leaks and retest repaired sections at no additional cost to OWNER, including damage due to testing.

D. Placing in Service: Prior to placing piping in service, disconnect the piping from all equipment and flush all construction debris from the system.

3.09 CLEANING

A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines with water to remove accumulated construction debris and other foreign matter.

B. Flush until all foreign matter is removed from the pipeline.

C. Provide hoses, temporary pipes, ditches and other items as required to properly dispose of flushing water without damage to adjacent properties.

D. Minimum Flushing Velocity: 2.5 fps.

E. For large diameter pipe where it is impractical to flush the pipe at 2.5 fps velocity, clean the pipeline in-place from the inside by brushing and sweeping, then flush the line at a lower velocity.

3.10 SCHEDULES (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15072

LARGE STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes furnishing and installation of steel pipe 12-in. in diameter and larger, fittings and appurtenances as indicated and specified.

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.

AMERICAN WELDING SOCIETY (AWS)

AWS B2.1	Standard for Welding Procedure and Performance Qualification
AWS D1.1	Structural Welding Code - Steel

MANUFACTURER'S STANDARDIZATION SOCIETY OF THE VALVES AND FITTINGS INDUSTRY (MSS)

MSS	Standard Practice SP-58 (Hangers and Supports)
MSS	Standard Practice SP-69 (Selection of Hangers and Supports)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A53	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A283	Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A307	Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile
ASTM A181	Specification for Forgings, Carbon Steel, for General Purpose Piping
ASTM A139	Specification for Electric Fusion (ARC) Welded Steel Pipe (NPS in 4 in. and Over)
ASTM A325	Specification for High Strength Bolts for Structural Steel Joints

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C200	Standard for Steel Water Pipe, 6 Inches and Larger

AWWA C205	Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4-in. and Larger – Shop Applied
AWWA C206	Standard for Field Welding of Steel Water Pipe
AWWA C207	Standard for Steel Pipe Flanges for Waterworks Service, sizes 4in. through 144in
AWWA C208	Standard for Dimensions for Steel Water Pipe Fittings
AWWA C209	Standard for Cold Applied Tape Coatings for Special Sections, Connections and fittings for Steel Water Pipelines
AWWA C213	Standard for Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C214	Standard for Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C222	Polyurethane Coatings for the Interior and Exterior of Steel Pipe and Fittings
AWWA C602	Standard for Cement-Mortar Lining of Water Pipelines - 4-in. and Larger In Place
AWWA M11	Steel Pipe – A Guide to Design and Installation

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B31.1	Power Piping
ANSI B1.1	Unified Screw Threads
ANSI B18.2.2	Square and Hex Nuts

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME	Boiler and Pressure Vessel Code Section IX.

STEEL STRUCTURAL STEEL PAINTING COUNCIL (SSPC)

SSPC-SP5	Surface Preparation Specification No. 5 **–** White Metal Blast Cleaning
SSPC-SP10	Surface Preparation Specification No. 10 **–** Near-White Blast Cleaning

1.04 DEFINITIONS (NOT USED)

1.05 DESIGN AND PERFORMANCE CRITERIA

A. Design Requirements

1. Pipe and fittings shall be designed in compliance with AWWA M11 to withstand the most critical simultaneous application for external loads and internal pressure under design conditions as shown on the PLANS and specified in this or any other Section as follows:
   a. Internal Loading
      (1) Design working pressure shall be 150 psi or greater unless otherwise indicated on the pipeline schedule shown on the

drawing.

(2) Surge allowance shall be 50 percent of design pressure unless otherwise indicated.

(3) Test pressure shall be as indicated on PLANS.

(4) Water temperature – 90° F maximum, 40° F minimum.

b. Maximum Working Stress

(1) The stress due to design pressure shall be no greater than 50 percent of the minimum yield strength. However, regardless of the yield strength of the steel, the maximum combined stress based on design pressure shall not exceed 21,000 psi.

c. Maximum deflection = 2% of the pipe diameter for cement coated steel pipe and 3% for dielectric coated pipe. Maximum deflection shall be calculated using moment of inertia of steel section of pipe wall and cement mortar lining, per AWWA M11.

d. Wall thickness of the steel pipe shall be determined based on design conditions for internal pressure and external loads and minimum thickness required for handling, as determined per AWWA M11.

e. Pipe Lengths. In general, steel pipe for underground installation shall be fabricated in manufacturer's standard joint lengths, but not longer than 50 feet.

2. Minimum wall thickness shall not be less than determined by wall thickness design requirements above or as specified in 2.02/B and on PLANS, whichever is the greatest.

1.06 SUBMITTALS

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

1. In addition to the items specified in Section 01300 "Submittals", furnish the following information:

a. Piping layouts in full detail showing dimensions, wall thickness, reinforcing at openings, types of coatings on each component, and lining. Show locations of longitudinal, spiral, and circumferential joints in pipe and specials. Provide materials of construction, with ASTM or API reference and grade, coatings and linings, and welds dimensioned in accordance with AWS A2.4. Show the centerline station and elevation to each pipe and pipe special, including within the limits of each horizontal or vertical curve and at changes of grade or elevation, will be laid.

b. Location of pipe hangers and supports.

c. Location and type of backup block or device to prevent joint separation. Details of joints, including butt-straps, couplings, flanges, and expansion joints.

d. 1/2" = 1'-0" scale details of all wall penetrations and fabricated fittings.

e. Pipe design data, including calculations and the test data demonstrating the fabrication of pipe and fittings meets or exceeds the requirements specified, including but not limited to pipe wall thickness, fitting reinforcement, and conformance with AWWA requirements. Design calculations to be sealed by a Professional Engineer licensed in the State of Texas. Provide certificate of conformance as required in Paragraph 1.07 Quality Assurance.

f. Schedules of all pipe, fittings, special castings, couplings, expansion joints, and all appurtenances specified or indicated.

g. Sworn certificates in duplicate of shop tests showing compliance with appropriate standard.

h. Reports for welding certifications per ANSI B31.1 Paragraph 127.6.

i. Catalog cuts of joints, couplings, harnesses, expansion joints, gaskets, fasteners and other accessories.

j. Brochures and technical data on coatings and linings and proposed method for application and repair.
k. As-built drawings.
l. Submit certified copies of test data and results and inspection reports with each shipment of pipe and specials. Test data and results and inspection reports shall be traceable to specific pipe lots or pieces.
m. Submit affidavit of compliance with referenced standards (e.g. ASTM A53, AWWA C200, etc.)
n. Submit welding procedure Specifications (WPS) and procedure qualification records for each welding process and welder qualification records (WQR) for each welder and welding operator.
o. Submit manufacturer's certificates of compliance for each lot of welding consumables used for shop and field welding.
p. Submit certified original copies of mill test reports on each heat of steel from which pipe is manufactured. Tests shall include physical and chemical properties. Submit certified original copies of mill test reports for flanges including details of stress relief used. Submit manufacturer's certificates of compliance with referenced standards, e.g. ASTM A53, ASTM A139, etc. Provide recertification by an independent domestic testing laboratory for materials originating outside the United States.
q. Submit manufacturing, fabricating and shipping schedule of all pipe and specials. Submit installation schedule.

1.07 QUALITY ASSURANCE

A. Pipe Manufacturer's Qualifications:

1. Manufacturers of pipe larger than 24-inch diameter shall have a quality control program consisting of one or more of the following: 1) a quality management system certified by the American National Standards Institute (ANSI) or National Sanitation Foundation (NSF) to comply with ISO 9001:2000, 2) a quality control program approved by the OWNER prior to submittal of bids for the PROJECT, or 3) an independent, third party quality control testing and inspection firm for testing and inspecting pipe produced for the PROJECT and approved by the OWNER prior to submittal of bids for the PROJECT. All such quality control programs shall be paid for by the manufacturer. It is the intent of this requirement that the manufacturer will document all appropriate tests and inspections with sampling and inspection criteria, frequency of testing and inspection, date of testing and inspection and date on which every piece was manufactured. Required testing and inspection, including that by an independent, third party, shall be performed full-time during production of pipe for the PROJECT. When requested by the OWNER, the manufacturer will provide copies of test data and results and inspection reports with the shipment of pipe for the PROJECT. Test data and results and inspection reports shall be traceable to specific pipe lots or pieces. OWNER approval of the manufacturer's quality control program will expire after three years, at which time the manufacturer must present a current quality control program for approval. The quality of materials, the process of manufacture and the finished pipe shall be subject to inspection and approval by the ENGINEER at the pipe manufacturing plant and at the project site prior to and during installation. Plant inspections shall be conducted at the discretion of the OWNER. Only manufacturers having a quality control program of the type described above will be considered as approved providers of products.
2. Pipe lining and coating is an element of the completed pipe. All pipe shall be completely lined and coated at the place of manufacturer.
3. 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 certificate signed and sealed by same ENGINEER stating that the computations and drawings are in conformance with specified design criteria.

B. Welder Qualifications:
   1. Qualify and certify welding procedures, welders, and operators in accordance with ANSI B31.1, Paragraph 127.5, for shop and project site welding of piping work.
   2. Qualification for welders: Welding shall be performed by welders holding current certification for the welding procedures in use.
   3. Visually inspect welding while the operators are making the welds and again after the work is completed. After the welding is completed, hand or power wire brush welds and clean them before the inspector makes the check inspection. Inspect welds for defects exceeding tolerances allowed by code under which the weld was made. Repair all defects exceeding tolerance.

C. Job Conditions:
   1. Coordinate dimensions and drillings of flanges with flanges for valves, pumps, and other equipment to be installed in piping system.

1.08 DELIVERY, STORAGE AND HANDLING

A. Shipping:
   1. Piping with flanged ends shall be protected with blank wooden or fiberboard flange protectors. Backing flanges are to be secured to the pipe ends.
   2. Pipe spools shall be loaded and blocked and lagged as necessary to ensure protection against damage during shipping.
   3. Loose parts (couplings, nuts and bolts, gaskets, etc.) shall be shipped in crates that are clearly marked as to contents.

B. Handling and Unloading:
   1. Unload and handle piping in accordance with pipe manufacturer's written instructions to protect lining and coating.
   2. Transfer of pipe shall be accomplished utilizing nylon straps or steel cables.
   3. Exercise extra care when handling flanged pieces due to the additional loads imparted by the flanges. Insert blocking or other means to support the flanges independently of the pipe to prevent the weight of the flange from distorting the pipe.
   4. Maintain plugs and flange protectors in openings to protect the pipe.
   5. Do not dump piping off of transport vehicle. Any damaged, chipped, or cracked fittings or pipe shall be returned to the place of manufacturer and replaced at CONTRACTOR's expense.

C. Storage:
   1. Store in an area that will avoid damage.
   2. Avoid contact with other materials.
   3. Store at job site on minimum 4″ × 4″ blocking at 6′ spacing. Piping smaller than 24-inch diameter may be stacked a maximum of three rows high as long as 4″ high spacers are used on 6′ centers.
   4. Keep interior of piping free of all foreign matter.

1.09 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following manufacturers meet the Quality Assurance requirements of part 1.07.A.1,

provided they submit an unexpired copy of the indicated certificate with the pipe submittal:

1. American SpiralWeld Pipe Company (SPFA Certificate No. 113683)
2. Ameron International Water Transmission Group (SPFA Certificate No. 113688)
3. Hanson Pressure Pipe (SPFA Certificate No. 113619)
4. Northwest Pipe Company (ISO 9001: 2000 Certificate No. 33609)

2.02 MATERIALS AND/OR EQUIPMENT

A. Steel pipe 10-inch thru 24-inch: ASTM A 53 Type E or S, Grade B, Black.

B. Steel Pipe 30-inch diameter and larger: Fabricated in accordance with AWWA C200; Steel plate, sheet or coil for fabricated pipe shall have a minimum yield strength of 42,000 psi. Unless otherwise noted on PLANS, steel pipe thickness shall meet or exceed the values shown in the table below:

Nominal Size	Minimum Wall Thickness	
	Interior	Buried
30-in	0.250	0.188
36-in	0.250	0.218
42-in	0.250	0.250
48-in.	0.250	0.250
54-in.	0.312	0.312
60-in.	0.312	0.344
66-in.	0.375	0.375
72-in.	0.375	0.438
78-in	0.50	0.50
84-in.	0.50	0.50
90-in.	0.50	0.50
96-in.	0.50	0.50
102-in	0.50	0.50
108-in	0.50	0.50

C. Interior piping wall thickness: Increase as required to limit combined stress (circumferential longitudinal and localized) to 2/3 of the minimum yield of the steel used.

2.03 PIPE: Fabricate to sizes, dimensions, and shapes indicated

A. Sizes, Pipe, Fittings and Specials:
1. 12 inch and smaller: Nominal.
2. 14 inch and larger: Actual outside diameter.
3. 30 inch and larger: Nominal size shall be I.D. or lining.

B. Seams:
1. Except for seamless mill type pipe, provide piping fabricated from steel plates rolled into cylinders or sections thereof with longitudinal seams or spiral seams butt welded. Fabricate the pipe cylinder by full-penetration butt-welding, spiral seam or straight seam.
2. Do not use more than two longitudinal seams in piping 72 in. and smaller in size. When using spiral seams, coil splices shall be a minimum of two (2) feet away from the ends of the pipe cylinder.
3. Butt weld girth seams shall be at least 6 ft. apart, except in specials and fittings. Shop seams shall be full-penetration double butt-welded. The bead on the outside of the pipe shall have a height of at least 1/16 inch and a minimum width of at least one and one-half times the thickness of the plate.
4. Take special care in the layout of joints in which fillet welds are to be used in

order to ensure the fusion of weld material at the bottom of the fillet. Prior to welding, fit the plates closely. Regardless of the joint type, during welding, hold them firmly together.

5. Prior to welding, clean the surfaces of plates and sheets to be welded by an automatic process of all scale and rust for a distance of one inch and of all oil and grease and contaminants for a distance of not less than 3 inches from the welding edge. Do not use petroleum solvent or kerosene to remove grease or oil.
6. The offset between edges to be joined shall not exceed 1/16 inch at circumferential joints and shall not exceed 1/32 inch at longitudinal seams. There shall be no valley, groove, or undercut along the edge of or the center of the weld. The deposited metal shall be fused smoothly and uniformly into the plate surface at the edges of the joint.

2.04 FITTINGS: Fabricate in accordance with AWWA C208

A. Unless shown otherwise on drawings, fittings shall comply with ASME B16.9 or shall be fabricated in accordance with AWWAC208 as follows:

1. Provide elbows with a radius of 2-1/2 times nominal diameter, unless otherwise indicated or specified. Provide elbows in accordance to the following:

Bend (degrees)	Number of Pieces
0 to 22-1/2	2
23 to 45	3
46 to 67-1/2	4
68 to 90	5

2. Reinforce tees, laterals, and outlets 42-inches and smaller in accordance with ASME B31.3, paragraph 304.3 and Appendix H. Reinforce tees, laterals, and outlets larger than 18-inches in diameter in accordance with the following:
   a. Where the ratio of diameter of the outlet to the diameter of the main run does not exceed 0.5, reinforce with a collar welded to the steel cylinder. Minimum width of the collar shall be one half the diameter of the outlet. Minimum thickness of the collar shall be the thickness of the cylinder.
   b. Where the ratio of diameter of the outlet to the diameter of the main run does not exceed 0.7, reinforce with a wrapper plate welded around the steel cylinder. Minimum width of the wrapper shall be one half the diameter of the outlet. Minimum thickness of the wrapper shall be the thickness of the cylinder.
   c. Where the ratio of diameter of the outlet to the diameter of the main run exceeds 0.7, reinforce with a crotch plate. Base crotch plate design on Swanson, H. S. et. al., *Design of Wye Branches for Steel Pipes*, Summarized in AWWA M11 (2004 ed.), Chapter 13. Stress relieve crotch plates in accordance with the ASME pressure Vessel Code, Section VIII, Part UW.
3. Provide reducing sections with same shell thicknesses required for larger ends.
4. Special Sections:
   a. Provide fittings and special sections with ends as indicated and fabricated to shapes, sizes, and dimensions indicated.
   b. The welded joint connecting nozzles, outlets and manways to the pipe shall be full penetration welded extending through the entire thickness of the main pipe shell, and welded both sides. All shell seams shall be butt welds. Butt welds shall be full penetration with 100% fusion through the

full thickness of the metal. Do not use lap welds.

c. Do not place longitudinal welds in steel plate sections adjacent to longitudinal or spiral seams in the adjacent section. Offset seams at least 30 degrees.

d. There shall be no girth seams at supports. No shell seam shall intersect or pass through manhole or nozzle connections.

e. Full penetration welds shall have at least three layers of weld metal. Clean welds between passes with a power grinding wheel.

f. Clean areas to be welded in accordance with NACE SP0178-2007, Section 5. Remove mill scale, weld flux, and weld spatter. Welds inside pipe to be lined with epoxy or polyurethane shall be ground flush. Apply weld metal to fill in undercuts and pits. Check finished weld with LP testing.

5. Small Branch Connections:

a. Provide branch connections 2-1/2 in. and smaller fabricated with welding fittings with threaded outlets.

b. Provide branch connections 3 in. through 12 in. fabricated with pipe nipples or with welding fittings.

c. Provide pipe nipples and welding fittings welded to pipe shell and reinforced to meet working and test pressure requirements.

d. Provide seamless pipe nipples of Schedule 40 black steel pipe in accordance with ASTM A53 unless otherwise specified.

e. Provide threaded and welded outlets as indicated.

f. Provide small branch connections located so as not to interfere with joints, supports, or other details.

6. Provide fittings shop fabricated from previously hydrostatically tested straight pipe. Perform magnetic particle test of all welds that were not previously tested in the straight pipe.

B. Reinforce tees, laterals, and outlets in accordance with AWWA M11 (4th Edition), Chapter 13, “Supplementary Design Data and Details”.

2.05 FIELD JOINTS

A. Type as indicated:

1. Location and type of joint may be modified to provide for lining, coating and flexibility in field assembly as approved by the ENGINEER.

B. Provide pipe end preparation and tolerances in accordance with AWWA C200.

2.06 FLANGES

A. Provide in accordance with AWWA C207, Class D, or E, depending on pressures as shown on PLANS.

B. Provide flanged end pipe fitted with slip-on flanges. Grind longitudinal or spiral welds flush to accommodate type of flanges provided. Liquid penetrant or magnetic particle test all welds ground flush for flange clearance prior to fit up to flange.

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 bolt ends 1/4 in. beyond surface of nuts.
3. Provide hexagonal nuts with dimensions in accordance with ANSI B18.2 and coarse threads in accordance with ANSI B1.1.

C. Face and finish flanges flat to a plane surface.

D. Provide flanges attached normal to axis of pipe for alignment.

E. Provide flanges tested, after welding to pipe, for true plane and reface, to bring them within specified tolerances.

F. Blind Flanges: Conforming in diameter, drilling, and thickness to flanges to which they mate and reinforced to produce a watertight joint under test pressures indicated in the Process Pipe Schedule.

G. Gaskets:
1. Provide full face ring-type flange gaskets made from 1/8-in. thick compressed non-asbestos material.

2.07 WELDED JOINTS

A. Welds:
1. Welds shall be sound and free from embedded scale or slag, with tensile strength of weld not less than that of thinner of connected sections.

B. Field welding of lined pipe is required. CONTRACTOR shall coordinate with fabricator to have pipe lining installation stop a minimum of 12 inches from end of pipe. Pipe connection shall be field welded, cleaned and tested. After acceptance of field, weld, installation of lining shall be completed in the field.

C. Field welds of interior piping: Butt welds.
1. Outside back-up bar may be used.

D. Field welds of buried piping: Butt welds, unless otherwise indicated on PLANs.

E. Complete field welds, in accordance with AWWA C206.

F. Welding electrodes for carbon steel pipe and fabrications not completed by submerged-arc welding shall comply with AWS A5.1.

2.08 SLEEVE TYPE COUPLINGS

A. Joints for lined piping:
1. Provide sleeve couplings when shown on construction PLANS.

B. Manufacturers:
1. Dresser Style 38.
2. Baker.
3. Viking Johnson.
4. Or equal.

C. Plain end type ends shall be joined by mechanical couplings in accordance with AWWA C200.
1. Outside diameter and out-of-round tolerances shall be within limits specified by coupling manufacturer.
2. Fabricate lugs from with ASTM A36 steel or acceptable equivalent product, as detailed in PLANS.
3. Provide hardened steel washers in accordance with ASTM A325.
4. Nuts and bolts:
   a. 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.
   b. Project bolt ends 1/4 in. beyond surface of nuts.

c. Provide hexagonal nuts with dimensions in accordance with ANSI B18.2.2 and coarse threads in accordance with ANSI B1.1.

D. Provide middle ring of each mechanical coupling with a thickness at least equal to that specified for size of pipe on which coupling is used and not 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.
1. Omit pipe stop from inner surface of middle rings of couplings to permit removal of valves, flow meters, and other installed equipment.
2. Provide pipe stops in other couplings.

E. Provide cleaning and shop priming with manufacturer's standard rust inhibitive primer.

F. Where noted or indicated, provide mechanically coupled steel pipe joints anchored to steel pipe with harness bolts. Weld harness lugs to steel pipe prior to application of lining.
1. Joint harness bolts: Provide harness lugs placed and provide harness bolts of length such that coupling can be slipped at least in one direction to clear joint. Provide harnesses of sufficient number and strength to withstand test pressure indicated in Process Pipe Schedule.
2. Provide a minimum of two 5/8-in. diameter bolts.

2.09 FLANGED COUPLING ADAPTERS

A. Manufacturers:
1. Dresser "Style 128."
2. Baker.
3. Viking Johnson.
4. Or equal.

B. Provide restrained flanged coupling adapters.

C. Provide tie rods of sufficient number and strength to restrain coupling at test pressure as indicated in Construction PLANS.

D. Provide a minimum of two 5/8-in. diameter tie rods at connections.

2.10 EXPANSION JOINTS

A. Manufacturers:
1. Mechanical Expansion Joints:
a. Dresser "Style 63."
b. Baker.
c. Viking Johnson.
d. Or equal.
2. Flexible Connectors and Bellows Expansion Joints:
a. Unaflex.
b. General Rubber.
c. Mercer.
d. Or equal.

B. Materials:
1. Joint movements of .4375 in. or greater and rotations of 1/2-degree or greater to be located as indicated or specified. Provide all other joints to allow a minimum of 0.4375 in. pipe expansion (joint compression) and pipe compression (joint expansion). Provide in accordance with Fluid Sealing Association, Series B for Bellows expansion joints.
2. Provide single arch Bellows joints at equipment for isolation design in

accordance with Fluid Sealing Association, Series B.

3. Provide tie rods at flexible connectors and expansion joints of sufficient number and strength to restrain connection at test pressure as indicated in PLANS. Provide a minimum of two 5/8-in. diameter tie rods at connections, unless otherwise shown on PLANS. Provide tie rods placed to provide movement at hinged expansion joints where movements cause lateral rotation of the expansion joint occur. Angle of rotation as indicated.
4. Provide flexible connectors and expansion joints guided in accordance with manufacturer's recommendations.
5. Elastomer material to be compatible with the flowing medium and the operating temperature as indicated in PLANS.

2.11 LINING AND COATING

A. Lining:
   1. Provide lining to the interior of steel pipe, fittings, sleeve couplings and outlets.
   2. When required by the Contract Documents, provide 100% solids polyurethane lining in locations noted on PLANS, according to AWWA C222, with minimum thickness of 50 Mils. Apply ITW Futura, Protec II PW, Madison, Corropipe II PW, or approved equal.
   3. Provide cement mortar lining, in locations noted on PLANS, according to AWWA C205.

B. Provide coating to the exterior of steel pipe, fittings, sleeve couplings and outlets in accordance with Section 09902.

PART 3 EXECUTION

3.01 SHOP TESTING

A. General: After completion of fabrication and welding in the shop, and prior to the application of any lining or coating, test each component according to the following requirements.

B. Shop Test Requirements:
   1. Test production welds in accordance with AWWA C200 for each heat of steel used. A guided-bend test specimen shall be considered as having passed only if no crack or other open defect exceeding 1/8-inch measured in any direction is present in the weld metal or heat affected zone of the base material after the bending. A tension test specimen shall be considered as having passed only if failure occurs in the base metal at a stress in excess of the minimum specified tensile strength. There shall be at least one set of welding tests as described in AWWA C200, Section 3.3.5 for each 1,000 linear feet of spiral seam weld in addition to tests specified in Section 3.3.6 of the same standard.
   2. Test each straight pipe section in the shop by the hydrostatic test method.
   3. Inspect all welds in the expanded portion of the pipe bell in accordance with the magnetic particle test.
   4. Test back gouge and completed weld of all manual process groove welds by the liquid penetrant method. Test completed fillet welds by the liquid penetrant method.
   5. Any production weld or manual process weld that appears to be of poor quality as determined by OWNER shall be subjected to 100 percent radiographic testing. One hundred percent ultrasonic testing may be used in lieu of 100 percent radiographic testing.
   6. After shop fabrication, retest each pipe section with a mitered bend or reducer. Test the mitered or butt joints by 100 percent radiographic testing.

7. After shop fabrication, retest each pipe section with an attached outlet. Test the collar or wrapper with the soap and compressed air method. Test the outlet by the liquid penetrant method.
8. Test each slip-on or ring type flange welded to the pipe by the liquid penetrant method and with the soap and compressed air method.
9. Prior to release from shop, all fabricated pieces must provide evidence of acceptable shop hydrostatic test or 100 percent radiographic testing of all welds.

C. Test Methods:

1. Shop Hydrostatic Test: Vent air from the pipe section before the test pressure is applied. Hold the test pressure on each section for a sufficient length of time to permit inspection of all joints.
2. Use the following hydrostatic test pressure for testing straight pipe sections:

$$P = \frac{2ST}{D}$$

Where P = Hydrostatic test pressure, PSI
S = Stress, PSI, use 75% of the minimum yield point of the steel
T = Wall thickness of the steel pipe section to be tested in inches
D = Actual outside diameter of the steel pipe section to be tested in inches

3. When subjected to the above hydrostatic test pressure, the pipe shall show no leaks, distortion, or other defects. Repair any leaks or other defects which develop during the hydrostatic test by chipping out and rewelding, after which the repaired section shall again be tested until it shows no leaks or other defects.
4. Test Bulkheads: Furnish and attach suitable dished heads and blind flanges for making the hydrostatic tests, and after completion of the test, remove the heads and properly restore the ends of the sections.
5. Radiographic Test: Make the radiographs in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels. Repair defects in the welds disclosed by the radiographs. Submit all radiographs and the notation of areas for repair to OWNER for review.
6. Ultrasonic Test: Make the ultrasonic tests in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels. Repair defects in the welds disclosed by ultrasonic testing. Prepare a report of the ultrasonic testing and submit to OWNER for review.
7. Soap and Compressed Air Test: Use compressed air at maximum 40-psi pressure into the joint, and while the joint is under pressure, swab every portion of every welded seam forming a part of the joint with a heavy soap solution or a commercial bubble-producing leak test fluid. Examine for leakage. Repair any defects disclosed by the test by chipping out, rewelding the chipped section, and retesting. Drill and tap the necessary test holes, and plug weld the holes after testing.
8. Liquid Penetrant Test: Conform to the requirements specified in ASTM E 165, Method B. The materials used shall be either water washable or nonflammable. Products: “Spotcheck” by the Magnaflux Corporation or equal. Chip out all defects, reweld, and retest the section affected until it shows no leaks or other defects.
9. Magnetic Particle Test: Magnetic particle test shall conform to the requirements specified in ASTM E 709, using the wet particle technique. Chip out all defects, reweld, and retest the section affected until it shows no leaks or other defects.

3.02 INSTALLATION OF PIPE

A. Install pipelines in accordance with PLANS. Install piping to lines and grades indicated and support. Where temporary supports are used, provide temporary supports as specified in Contract Documents to prevent shifting or distortion of pipe. Provide for expansion.

B. Protect the pipe lining and coating from weld spatter.

C. During pipe laying operations, do not place tools, food, clothing, trash, or other materials in the pipe. When pipe laying operations are not in progress, close the pipe ends with a child-and-vermin-proof plug.

D. Before flanges are assembled, remove rust resistant coating from machined surfaces clean gaskets and smooth burrs. Make up flanged joints tight, and prevent strain upon valves or other pieces of equipment.

E. Install tierods, pipe clamps or bridles when sleeve type couplings or fittings are used in piping system as indicated, and at changes in direction or other places to prevent joints from pulling apart under pressures indicated in PLANS.

F. Examine pieces for damage. Do not install pieces that are damaged. If any damaged piece should be discovered after having been installed, remove and replace with a sound piece at no additional cost to the OWNER.

G. Handle pipe with equipment such as nylon slings and padded skids, designed to prevent damage to the coating. Repair abrasions and injuries to the coating prior to the application of insulation or prior to the application of final field coating.

H. Provide welded joints where detailed on the PLANS. Field trimming shall not be done without written permission of the OWNER, and when done, shall be normal to the axis of the pipe. Preheat the joints to be welded in accordance with Table 1 of AWWA C206. Complete each pass around the entire circumference of the pipe before commencing the next pass. Do not deposit more than 1/8 inch of throat thickness per pass. Clean each layer of deposited weld metal prior to depositing the next layer of weld metal, by a power-driven wire brush. Where interior joint welds are detailed in the drawings, backfill to one (1) foot over the pipe except at the joints. Complete the interior weld prior to completing the exterior coating.

I. Provide closure lap joints at intervals not to exceed 500 feet either by lengthening the bell to provide three (3) inches of longitudinal adjustment beyond the normal lap-joint requirement or by using a butt strap. Set the special closure lap joints so that the pipe will be stabbed deeper than the normal closed position to such an extent that upon cooling and contraction of the pipe, the final closure-joint weld may be made at the approximate normal closed position. Weld all pipe joints either side of the closure joints. Weld the closure joints during the coolest hour of the 24-hour day. When possible, the closure-joint welds shall be made when the steel temperature is approximately equal to the lowest operating temperature.

J. All field welds shall be performed to the same procedures and requirements defined for shop fabrication. All field welds shall be tested by 100 percent radiographic testing.

3.03 INSTALLATION OF LINING AND COATING

A. After installation of pipe, fittings, and specials, clean, prime, line, and coat as specified for pipe adjacent to weld. Coat unlined or uncoated ends adjacent to field welded joints, including weld proper. Repair any damage to lining in accordance with lining manufacturers written recommendations.

B. Preparation of surfaces to be lined and coated after installation of pipe shall be the same as required for shop application of coating. Remove foreign matter, including all weld spatter and damaged lining or coating materials, by scraping, chipping, or brushing. Clean all surfaces to bright metal free of all rust, slag, and scale by means of wire brushing or sand blasting.

C. Use open ends or access manholes for entry for application of interior linings to unlined ends.

D. Pour holes are not allowed.

E. After installation of pipe, fittings, and specials, shop coat on exterior shall be touched up followed by a field coat prior to encasing in concrete.

3.04 INSTALLATION OF FLANGED COUPLING ADAPTERS

A. Install flange coupling adapters in strict accordance with coupling manufacturer's recommendations.

3.05 INSTALLATION OF PIPE SUPPORTS

A. Provide in accordance with applicable pipe support Specification.

B. Proceed with installation of pipe supports only after required building structural work has been completed and concrete has reached its 28 day compressive strength.

C. Support piping to prevent forces applied on valves and equipment.

3.06 PHYSICAL CHECKOUT, FIELD AND FUNCTIONAL TESTING

A. Clean dirt, dust, oil, grease and other foreign material, before pressure and leakage tests.

B. Water for testing provided by the CONTRACTOR.

C. Pressure and Leakage Tests:
1. Provide temporary testing plugs or caps; pressure pumps, pipe connections, meters, gages, equipment, and labor.
2. Test pipelines in sections of approved length.
3. Fill section of pipe with water and expel air.
4. Pressure and leakage test consists of first raising pressure (based on elevation of lowest point of section under test and corrected to gage location) to pressure in psi numerically equal to test pressures indicated in the Process Pipe Schedule.
5. No visible leakage in joint is acceptable.
6. If unable to achieve and maintain specified pressure for one hour with no additional pumping, section has failed to pass test.
7. If section fails pressure and/or leakage test, locate, uncover, and repair or replace defective pipe, fitting, or joint, and conduct additional tests and repairs until section passes test at no additional cost and without any time extensions.

D. Make piping connections to equipment with pipe in a free supported state and without application of vertical or horizontal forces to align piping with the equipment flanges.

3.07 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15074

VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Housed spring mounts.
4. Elastomeric hangers.
5. Spring hangers with vertical-limit stops.

1.2 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. Product Data: For each product indicated.

C. Welding certificates.

D. Qualification Data: For professional engineer.

E. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

F. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

G. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

H. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch-thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

I. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch-thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

2.3 VIBRATION-CONTROL DEVICE INSTALLATION

A. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

B. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

2.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

2.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

PART 3 - EXECUTION

3.1 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 15074

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SECTION 15075

MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Furnish, mark, and install identification devices for all mechanical equipment, ducts, exposed piping, and valves using color bands, lettering, flow direction arrows, and related permanent identification devices, as specified herein. Mark existing equipment, ducts, piping, and valves when indicated on PLANS.

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 referenced in the text by basic designation only.

AMERICAN NATIONAL STANDARD INSTITUTE (ANSI)

ANSI A13.1	Scheme for the Identification of Piping Systems.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D709	Standard Specification for Laminated Thermosetting Materials

1.04 DEFINITIONS (NOT USED)

1.05 SYSTEM DESCRIPTION

A. Types of identification devices specified in this Section include the following:
1. Equipment Nameplates
2. Painted Identification Materials.
3. Plastic Pipe Markers.
4. Plastic Tape.
5. Valve Tags.
6. Valve Schedule Frames.
7. Engraved Plastic-Laminate Signs.
8. Plasticized Tags.
9. Special Items.
10. Underground Warning Tape

1.06 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, “Submittals” and Section 01730, “Operation and Maintenance Data”.
1. In addition to the items specified in Section 01300 “Submittals”, furnish the following information:
a. Product data: Manufacturer’s technical data and installation instructions for each identification material and device required.
b. Samples: Of all types and of each color, lettering style and other graphic representation required for each identification material or system to be used in the work.
c. A list of suggested wording for all valve tags prior to fabrication.

1.07 QUALITY ASSURANCE

A. Regulatory requirements:
   1. Comply with Texas Commission on Environmental Quality (TCEQ):
      a. Chapter 217 – Design Criteria for Wastewater Systems
      b. Chapter 290 - Public Drinking Water.
   2. Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.08 DELIVERY, STORAGE AND HANDLING

A. Delivery products to site in factory packed boxes or crates.

B. Store inside. Protect from weather and damage until installed.

1.09 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer: Subject to compliance with the requirements of this Section, provide mechanical identification materials from one of the following manufacturers.
   1. Allen Systems, Inc.
   2. Brady (W.H.) Co.; Signmark Div.
   3. Industrial Safety Supply Co., Inc.
   4. Seton Name Plate Corp.

2.02 MATERIALS AND/OR EQUIPMENT

A. General: Provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for application, selection is installer's option, but provide single selection for each product category.

B. Equipment Nameplates
   1. Material and fabrication:
      a. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.
   2. Fasteners:
      a. Number 4 or larger oval head stainless steel screws or drive pins.
   3. Text:
      a. Manufacturer's name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.

C. Painted Identification Materials:
   1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping and similar applications, but not less than 1¼″ high letters for ductwork and not less than 3/4″ high letters for access door signs and similar operational instructions.
   2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.
   3. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ANSI A13.1 for colors.

D. Plastic Pipe Markers:
   1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

2. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1.
3. Insulation: Furnish 1″ thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on non-insulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2″ beyond each end of plastic pipe marker.
4. Small Pipes: For external diameters less than 6″ (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
    a. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
    b. Adhesive lap joint in pipe marker overlap.
    c. Laminated or bonded application of pipe marker to pipe (or insulation).
    d. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4″ wide; full circle at both ends of pipe marker, tape lapped 1½″.
5. Large Pipes: For external diameters of 6″ and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:
    a. Laminated or bonded application of pipe marker to pipe (or insulation).
    b. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1½″ wide; full circle at both ends of pipe marker, tape lapped 3″.
    c. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.
6. Lettering: Comply with piping system nomenclature as specified, scheduled or shown, and abbreviate only as necessary for each application length.
    a. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as a separate unit of plastic.

E. Plastic Tape:
1. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.
2. Width: Provide 1½″ wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6″, 2½″ wide tape for larger pipes.
3. Color: Comply with ANSI A13.1, except where another color selection is indicated.

F. Valve Tags:
1. Provide 2″ diameter, 0.025″ thick, polished stainless steel valve tags with 3/16″ hole for mounting.
2. Marking:
    a. Scheduled Valves: Tags are to be stamped or engraved with the tag number listed in the valve schedule:
        1) First Line: Area code.
        2) Second Line: Equipment code.
        3) Third Line: Unit code.
        4) Lettering Height: 1/8″.
    b. Unscheduled Valves: Tags are to describe the service with a sequential number:
        1) First Line: Service - 1/4″ high lettering.
        2) Second Line: Sequential number - 1/2″ high lettering.
    c. Fill tag engraving with black enamel.

3. Valve Tag Fasteners:
    a. Stainless steel screws;
    b. Stainless steel nuts and bolts;
    c. Stainless steel wire (1/16″) with swagged terminations;
    d. No. 6 stainless steel beaded chain; or
    e. No. 16 stainless steel jack chain.
4. Access Panel Markers: Provide manufacturer's standard 1/16″ thick engraved plastic laminate access panel markers, with abbreviations, and numbers corresponding to concealed valve, unless otherwise required by code. Include 1/8″ center hole to allow attachment.

G. Valve Schedule Frames:
1. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

H. Engraved Plastic-Laminate Signs:
1. General: Provide engraving stock melamine plastic laminate, complying with ASTM D709, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
2. Thickness: 1/16″ for units up to 20 sq.in. or 8″ length; 1/8″ for larger units.
3. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

I. Plastic Equipment Markers:
1. General: Provide manufacturer's standard laminated plastic, color-coded equipment markers. Conform to the following color code.
    a. Green: Cooling equipment and components.
    b. Yellow: Heating equipment and components.
    c. Yellow/Green: Combination cooling and heating equipment and components.
    d. Brown: Energy reclamation equipment and components.
    e. Blue: Equipment and components that do not meet any of the above criteria.
    f. For hazardous equipment, use colors and designs recommended by ANSI A13.1.
2. Nomenclature: Include the following, matching terminology on schedules as closely as possible.
    a. Name and plan number.
    b. Equipment service.
    c. Design capacity.
    d. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.
3. Size: Provide approximate 2½″ × 4″ markers for control devices, dampers and valves; and 4½″ × 6″ for equipment.

J. Lettering and Graphics:
1. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.
    a. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (e.g., Boiler No. 3, Air Supply No. 1H, Standpipe F12).

K. Special Items
1. In addition, special coating of following items will be required:

Item	Color
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	In accordance with standard details

L. Underground Warning Tape
1. Material:
a. Metallic detection tape; minimum 4 mil thick by 6 inches wide polyethylene film with wording, “Caution” with name of service followed by words, “Line Buried Below” repeated continuously along tape length, with alternate metallic and color strips.

2.03 EXTRA STOCK

A. Furnish minimum of 5% extra stock of each mechanical identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.
1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

PART 3 EXECUTION

3.01 GENERAL

A. Install all labels and identification tags in accordance with the manufacturer’s printed instructions. Appearance to be neat and uniform. Tags and/or labels to be readily visible from normal working locations.

B. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.02 PREPARATION

A. Prepare and coat surfaces as Specified in Contract documents.

B. Prepare surface in accordance with product manufacturer's instructions.

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Existing Identification Systems: In installations where existing piping identification systems have been established, continue to use the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the specified system. The objective is to fully identify all new equipment, piping, valves, and appurtenances to the level specified herein.

B. Piping System Identification:
1. General: Pipe identification to consist of 4 elements - 2 color-coded bands, a lettered label, and a flow arrow to indicate direction of flow in the pipe. Color bands to be painted directly upon the pipe or of the pressure-sensitive, adhesive-backed, vinyl cloth or plastic tape type. Labels to be preprinted on pressure-sensitive, adhesive-backed, vinyl cloth or plastic tape. Arrows to be die-cut of the same type of material as the labels. Arrange bands so that the lettered label and the directional arrow are placed between the 2 bands. Install pipe markers of

one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow.

a. Stenciled markers, including color-coded background band or rectangle, and contrasting lettering of black or white. Extend color band or rectangle 2″ beyond ends of lettering.
b. Letter sizes and colors for lettering, arrows, and background to conform to ANSI A13.1.
c. Plastic pipe markers, with application system as indicated under "Materials" in this Section. Install on pipe insulation segment where required for hot non-insulated pipes.
d. Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided.

2. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
   a. Near each valve and control device.
   b. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
   c. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
   d. At access doors, manholes and similar access points which permit view of concealed piping.
   e. Near major equipment items and other points of origination and termination.
   f. Piping to be identified at intervals of 20 feet, and at least one time in each room. Identify piping at a point approximately within 2 feet of all turns, ells, valves, and on the upstream side of all distribution fittings or branches. Sections of pipe that are too short to be identified with color bands, lettered labels, and directional arrows are to be tagged and identified similar to valves.
   g. On piping above removable acoustical ceilings, except omit intermediately spaced markers.
3. Sections of pipe that are too short to be identified with color bands, lettered labels, and arrows are to be identified with metal or plastic tags as specified herein.

C. Valve Identification:
1. General: Provide valve tag on every valve, cock and control device in each piping system; exclude valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
2. Valve tags are to be permanently attached to the valve as follows:
   a. Valves 12-inches and Smaller: Attach tag to valve with SS beaded chain, SS jack chain, or SS wire.
   b. Valves Larger than 12-inches: Attach tag to valve using SS screw(s) or SS nuts and bolts.
3. Mount valve schedule frames and schedules in rooms where indicated or, if not otherwise indicated, where directed by ENGINEER.
   a. Where more than one major machine room is shown for project, install mounted valve schedule in each major machine room, and repeat only main valves which are to be operated in conjunction with operations of more than single machine room.

D. Equipment Identification:
1. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device, as

specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:

a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
b. Meters, gages, thermometers and similar units.
c. Fuel-burning units including boilers, furnaces, heaters, stills and absorption units.
d. Pumps, compressors, chillers, condensers and similar motor-driven units.
e. Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar equipment.
f. Fans, blowers, primary balancing dampers and mixing boxes.
g. Packaged HVAC central-station or zone-type units.
h. Tanks and pressure vessels.
i. Strainers, filters, humidifiers, water treatment systems and similar equipment.

2. Optional Sign Types: Where lettering larger than 1″ height is needed for proper identification, because of distance from normal location of required identification, stenciled signs may be provided in lieu of engraved plastic, at installer's option.
3. Lettering Size: Minimum 1/4″ high lettering for name of unit where viewing distance is less than 2′-0″, 2″ high for distances up to 6′-0″, and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.
4. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
   a. Operational valves and similar minor equipment items located in non-occupied spaces (including machine rooms) may, at installer's option, be identified by installation of plasticized tags in lieu of engraved plastic signs.

3.04 – 3.05 (NOT USED)

3.06 ADJUSTING

A. Relocate any mechanical identification device which has become visually blocked by work of other divisions.

3.07 CLEANING

A. Clean face of identification devices, and glass frames of valve charts.

3.08 - 3.10 (NOT USED)

3.11 MEASUREMENT AND PARMENT

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 15077

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.

1.2 SUBMITTAL

A. Product Data: For each type of product indicated.

B. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch Stainless steel, 0.025-inch Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, minimum 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch-thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Blue.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Condenser-Water Piping:

    a. Background Color: Green.
    b. Letter Color: White.

2. Refrigerant Piping:

a. Background Color: Yellow.
b. Letter Color: Black.

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 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 15077

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SECTION 15083

HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:

a. Flexible elastomeric.
b. Mineral fiber.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Sealants.
7. Factory-applied jackets.
8. Field-applied jackets.
9. Tapes.
10. Securements.
11. Corner angles.

B. Related Sections:
1. Division 15 Section 15815 "Metal Ducts" for duct liners.

1.2 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. Product Data: For each type of product indicated.

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

8. Detail field application for each equipment type.

D. Field quality-control reports.

1.3 QUALITY ASSURANCE

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

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 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. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

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

a. Aeroflex USA Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

G. 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. Manson Insulation Inc.; Alley Wrap.
    e. Owens Corning; All-Service Duct Wrap.

H. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

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. Johns Manville; HTB 23 Spin-Glas.
    b. Owens Corning; High Temperature Flexible Batt Insulations.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1-hour fire rating by a NRTL acceptable to authority having jurisdiction.

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.; FlameChek.
    b. Johns Manville; Firetemp Wrap.
    c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
    d. Thermal Ceramics; FireMaster Duct Wrap.
    e. 3M; Fire Barrier Wrap Products.
    f. Unifrax Corporation; FyreWrap.
    g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.

2.3 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

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. Insulco, Division of MFS, Inc.; SmoothKote.
    b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.

c. Rock Wool Manufacturing Company; Delta One Shot.

2.4 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. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

a. Aeroflex USA Inc.; Aeroseal.
b. Armacell LCC; 520 Adhesive.
c. Foster Products Corporation, H. B. Fuller Company; 85-75.
d. RBX Corporation; Rubatex Contact Adhesive.

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).

C. 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).

D. 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, 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 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.

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. Dow Chemical Company (The); 739, Dow Silicone.
    b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. P.I.C. Plastics, Inc.; Welding Adhesive.
    d. Speedline Corporation; Speedline Vinyl Adhesive.

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).

2.5 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 of 50 g/L or less when calculated 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, available products that may be incorporated into the Work include, but are not limited to, 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, available products that may be incorporated into the Work include, but are not limited to, 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.

2.6 SEALANTS

A. Joint Sealants:

B. FSK and Metal Jacket Flashing Sealants:

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-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).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

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-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.

Service Temperature Range: Minus 40 to plus 250 deg F.

4. Color: White.
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).

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
3. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

4. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.

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. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
    b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

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

    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto PVC Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

    a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

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; Metal Jacketing Systems.
    b. PABCO Metals Corporation; Surefit.
    c. RPR Products, Inc.; Insul-Mate.

2. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.
3. Finish and thickness are indicated in field-applied jacket schedules.
4. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
5. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
6. Factory-Fabricated Fitting Covers:

    a. Same material, finish, and thickness as jacket.
    b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    c. Tee covers.
    d. Flange and union covers.
    e. End caps.
    f. Beveled collars.
    g. Valve covers.
    h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of

a rubberized bituminous resin on a crosslaminated polyethylene film covered with stucco-embossed aluminum-foil facing.

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. Polyguard; Alumaguard 60.

F. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

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. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.

G. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

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. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
    b. Compac Corp.; 104 and 105.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. 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, available products that may be incorporated into the Work include, but are not limited to, 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.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

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. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
    b. Compac Corp.; 130.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
    d. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

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. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    b. Compac Corp.; 120.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
    d. Venture Tape; 3520 CW.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

2. Width: 3 inches.
3. Film Thickness: 4 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.

2. Width: 3 inches.
3. Film Thickness: 6 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

2.11 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing or closed seal.

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; Bands.
    b. PABCO Metals Corporation; Bands.
    c. RPR Products, Inc.; Bands.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
        2) GEMCO; Perforated Base.

3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
2) GEMCO; Press and Peel.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.

   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) GEMCO.
      2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.080-inch nickel-copper alloy.

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

   a. C & F Wire.
   b. Childers Products.
   c. PABCO Metals Corporation.
   d. RPR Products, Inc.

2.12 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, 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. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. 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.

1. Comply with requirements in NFPA.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in NFPA.

3.4 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.5 MINERAL-FIBER INSULATION INSTALLATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. 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, 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.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Impale insulation over pins and attach speed washers.
f. 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.

4. 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.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. 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.

5. 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.
6. 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.
7. 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.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

D. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Comply with NFPA.

3.8 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in 3.10 "Duct Insulation Schedule".
2. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one locations of straight pipe, one locations of welded fittings.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 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 nonconditioned space.
4. Indoor, exposed return located in nonconditioned space.
5. Outdoor, concealed supply and return.
6. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.

2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

C. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

D. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

E. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

F. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

3.12 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

C. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

D. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

E. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.

F. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 3 inches thick and 1.5-lb/cu. ft. nominal density.

3.13 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping: Flexible elastomeric, 1 inch thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing: Flexible elastomeric, 1 inch thick.

3.15 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping: Insulation shall be the following:
1. Flexible Elastomeric: 2 inches thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing: Insulation shall be the following:

1. Flexible Elastomeric: 2 inches thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. None.
2. PVC: 20 mils thick.
3. Aluminum, Stucco Embossed: 0.020 inch thick.

E. Piping, Concealed:

1. None.

F. Piping, Exposed:

1. None.
2. PVC: 20 mils thick.
3. Aluminum, Stucco Embossed: 0.020 inch thick.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.
2. Aluminum, Stucco Embossed: 0.020 inch thick.

D. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Stucco Embossed: 0.020 inch thick.

E. Piping, Concealed:
1. Aluminum, Stucco Embossed: 0.020 inch thick.

F. Piping, Exposed:

1. PVC: 20 mils thick.

3.18 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

3.19 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 15083

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SECTION 15100

VALVES AND OPERATORS

PART 1 – GENERAL

1.01 SUMMARY

Furnish and install valves, actuators, and all related accessories and appurtenances so as to provide a complete functioning system at each valve location as shown on PLANS and as specified. This Section includes basic requirements for valves.

1.02 RELATED REQUIREMENTS

A. PLANS indicate sizes, working pressures, type operator, and operating conditions for sizing operators.

B. Other related work as called for on PLANS or specified 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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A167	Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plat, Sheet, and Strip
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A351	Standard Specification for Castings Austenitic, Austenitic-Ferritic (Duplex), for Pressure Containing Parts
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM A582	Standard Specification for Free-Machining Stainless Steel Bars
ASTM D429	Standard Test Methods for Rubber Property - Adhesion to Rigid Substrates
ASTM D1784	Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2000	Standard Classification System for Rubber Products in Automotive Applications

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C111/A21.11	Standard Specification for Gray Cast Iron Casting for Valves, Flanges, and Pipe Fittings
AWWA C500	Metal-Seated Gate Valves for Water Supply Service
AWWA C504	Rubber-Seated Butterfly Valves
AWWA C508	Swing-Check Valves for Waterworks Service
AWWA C509	Resilient-Seated Gate Valves for Water Supply Service
AWWA C511	Reduced-Pressure Principle Backflow-Prevention Assembly
AWWA C540	Power-Actuating Devices for Valves and Sluice Gates
AWWA C550	Protective Epoxy Interior Coatings for Valves and Hydrants
AWWA C606	Grooved and Shouldered Joints

AMERICAN SOCIETY OF SANITARY ENGINEERS (ASSE)

ASSE Standard 1011	Performance Requirements for Hose Connection Vacuum Breakers

NATIONAL SCIENCE FOUNDATION

NSF 61	Drinking Water System Components – Health Effects

1.04 DEFINITIONS (NOT USED)

1.05 DESIGN AND PERFORMANCE CRITERIA

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
   2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections. Unless otherwise specified on PLANS provide as follows:
   1. Valves 3 inch nominal size and larger: Flanged ends, except underground valves.
   2. Valves less than 3 inch nominal size: Threaded ends.
   3. Plastic valves in plastic piping:
      a. Up to 2.5 inches: Provide solvent or heat welded unions.
      b. 3 inches and above: Provide solvent or heat welded flanges.

1.06 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 data sheets for make and model, including valve type, size, pressure rating, and Cv Factor.

b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
c. Certified drawing with description of component parts, dimensions, weights, coatings, and materials of construction
d. Power and control wiring diagrams, including terminals and numbers.
e. Complete motor nameplate data.
f. Sizing calculations for open-close/throttle and modulating.

2. Operation and Maintenance Manuals:
   a. Furnish installation, operation, and maintenance instructions for each type of manual valve 4-inch in nominal size and larger, and all non-manual valves. Include information on valve operators in operation and maintenance instruction manual.
3. Certifications:
   a. Certificate of Compliance for:
      1) Electric operators; full compliance with AWWA C540.
      2) Butterfly valves; full compliance with AWWA C504.
      3) NSF 61 for valves and coatings used in potable water applications.
   b. Tests and inspection data.
   c. Manufacturer's Certificate of Proper Installation.

B. The City of Austin Water and Wastewater Utility Standard Products Lists (SPL) are considered to form a part of these Specifications. Contractors may, when appropriate, elect to use products from the SPL; however, submittal to the Engineer/Architect (E/A) is still required. If the Contractor elects to use any materials from these lists, each product shall be completely and clearly identified by its corresponding SPL number when making the product submittal. This will expedite the review process in which the E/A, and, if necessary, the Water and Wastewater Utility Standard Products Committee, decide whether the products meet the Contract requirements and the specific use foreseen by the E/A in the design of this engineered Project. The SPL's should not be interpreted as being a pre-approved list of products necessarily meeting the requirements for a given construction Project. Items contained in the SPL cannot be substituted for items shown on the Drawings, or called for in the specifications, or specified in the Bidding Requirements, Contract Forms and Conditions of Contract, unless approved by the E/A in conjunction with the Water and Wastewater Utility Standard Products Committee. The Standard Product List current at the time of plan approval will govern.

1.07 QUALITY ASSURANCE

A. Standardization: All like equipment to be obtained from single manufacturer.

B. System Coordination: CONTRACTOR is responsible for all details necessary to properly install, adjust, and place in operation working systems.

C. All electric valve actuators shall be manufactured by the same manufacturer. CONTRACTOR shall coordinate among all suppliers of various equipment to ensure consistency within the construction contract. However, unit responsibility shall be maintained for each individual valve and gate including coordination of design, assembly, testing, and installation.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver, unload and store products on site in manner that prevents damage. Use special care to prevent damage from temperature and condensation.

B. Flanges to be protected by wooden blank flange protectors, strongly built and securely bolted thereto, or otherwise attached.

C. Storage and Protection:
   1. Store materials in original, unopened containers in compliance with manufacturer's printed instructions.
   2. Keep materials dry until ready for use. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.
   3. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

1.09 - 1.11 (NOT USED)

PART 2 - PRODUCTS

2.01 GENERAL

A. Valve to include operator, actuator, hand wheel, chain wheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, and accessories for a complete operation. Provide electric actuators as noted on the PLANS

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified and designed for long term operation in severe duty environment.

C. Valve same size as adjoining pipe.

D. Valve ends to suit adjacent piping.

E. Size operator to operate valve for the full range of working pressures indicated on applicable schedules.

F. Valve to open by turning counterclockwise.

G. All accessory items such as positioners, actuators, small diameter piping and tubing, limit switches shown, specified or required shall be factory mounted on the indicated valve and adjusted at the valve manufacturer's facility.

2.02 MATERIALS

A. General
   1. Stainless steel: In accordance with ASTM A 167, Type 316, or Type 304, UNS Alloy S31600 or S30400.
   2. Valve and operator bolts and nuts: Unless otherwise specified on PLANS provide as follows:
      a. Fabricated of stainless steel for the following installation conditions:
         1) Submerged in sewage or water.
         2) In an enclosed space above sewage or water.
         3) In structures containing sewage or water, below top of walls.
         4) At openings in concrete or metal decks.
      b. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
      c. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.
   3. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.
   4. Valve bodies: Cast iron in accordance with ASTM A126, Class 30 minimum or ductile iron in accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

B. Interior Protective Liner
1. Provide valves with type of protective lining specified in the particular valve Specification.
2. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.
3. Lining types:
a. Fusion bonded epoxy:
1) Manufacturers: The following or equal:
a) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
2) Fusion bonded, electrostatically applied epoxy per AWWA C550.
3) Clean surfaces in accordance with SSPC SP 7 or SP10, as recommended by epoxy manufacturer.
4) Apply in accordance with manufacturer's published instructions.
5) Lining thickness: 0.010 to 0.012 inches except that:
a) Lining thickness in grooves for gaskets: 0.005 inches.
b) Do not coat seat grooves in valves with bonded seat.
6) Quality control:
a) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
b) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
c) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
d) Correct defective lining disclosed by unsuccessful tests, and repeat test.
e) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.
b. High solids epoxy: As specified in Section 09902.

C. Underground Valves
1. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.
2. Coating and wrapping:
a. Prior to installation, coat buried valves with protective coating as specified in Section 09902, "Painting and Protective Coatings".
b. After installation, encase valves in 2 layers of polyethylene wrap in accordance with contract specifications for ductile iron piping.
1) Polyethylene wrapping shall not affect operation of valve.

D. Manual Operators:
1. General:
a. Operator force not to exceed 40 pounds under any operating conditions, including initial breakaway. Provide gear reduction operator when force exceeds 40 pounds.
b. Operator self-locking type or equipped with self-locking device.
c. Position indicator on quarter-turn valves.
d. Worm and gear operators: one-piece design worm-gears of gear bronze material. Worm hardened alloy steel with thread ground and polished.
e. Traveling nut type operators threaded steel reach rods with internally threaded bronze or ductile iron nut. Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual operators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.
f. Provisions for alternate operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve

operators or lifts for alternate operation with tripod mounted portable gate operators.

g. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve in open or closed position.

h. Open direction indicator: Cast arrow and legend indicating direction to rotate operator on handwheel, chain wheel rim, crank, or other prominent place.

2. Exposed operator:

a. Painted handwheels, minimum 24 inch diameter

b. Lever operators allowed on quarter-turn valves 8-inch and smaller, requiring maximum 25 pounds pull to operate valve

c. Cranks on gear type operators, 15 inch radius.

d. Chain wheel operator with tiebacks, extension stem, floor stands, and other accessories to permit operation from normal operation level.

e. Valve handles to take a padlock, and wheels a chain and padlock.

E. Buried operator:

1. Buried operator housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between operator housing and valve body so that no moving parts are exposed to soil.

2. Buried service operators on valves larger than 2½-inch shall have a 2-inch AWWA operating nut. Buried operators on valves 2½-inch and smaller shall have cross handle for operation by forked key.

3. Design buried service operators for quarter-turn valves to withstand 450 foot-pounds of input torque at the FULLY OPEN or FULLY CLOSED positions, grease packed and gasketed to withstand a submersion in water to 10 psi.

4. Buried valves shall have extension stems, bonnets, and valve boxes.

F. Electric Valve and Gate Operators

1. General:

a. Unless otherwise specified, operators shall be sized to move valves from full open to closed position at minimum 12 inches per minute, plus or minus 10 percent, under maximum operating load.

b. Actuator: Provide with built-in device to allow motor to reach full speed before engaging valve load; in manual operating mode when motor is not energized; in electrical operating mode when motor is energized.

c. Handwheels for manual operation: Metallic with arrows to indicate "OPEN" rotation; incapable of rotation during motor operation; unaffected by fused motor; maximum 80 pound pull on rim when rotating.

d. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing positively when motor is deenergized and freeing handwheel for manual operation.

e. Unless otherwise specified, provide units consisting of 480-volt, three-phase electric motor, gearbox, limit switches, torque switches, manual override handwheel with declutching lever, and mechanical position indicator.

f. Provide Quarter turn or multi-turn units equipped with gearing and mounting hardware as required by the associated valve.

g. Sized by the valve supplier and factory mounted. Sized to produce at least 1½ times the operating torque required. Stall torque of motor shall not exceed the torque capacity of the valve.

h. All material to be suitable for the environment in which the valve is to be installed. Where called for in the PLANs, motors and electrical enclosures shall be suitable for a Class I, Division 2, Group D location. All actuators shall be minimum NEMA 4 and suitable for wet and corrosive environments. A separately sealed terminal compartment shall

be provided to segregate the electronic and electrical components in the actuator from the incoming conduit.

i. Provide 120 volt condensation heaters in the limit switch, motor, and control compartments

j. Manufacturers (Reference single manufacturer requirement in Paragraph 1.07):
   1) Limitorque L120 (No Controls Unit)
   2) Beck (Equivalent)
   3) no equal

2. Actuator gearing:
   a. All gearing shall be of metal construction. The actuator shall be a single or double reduction unit consisting of spur or helical gears and worm-gearing. The spur or helical gears to be of hardened alloy steel and the worm-gear to be alloy bronze. All gearing shall be accurately cut with hobbing machines. Final output reduction worm gearing shall conform to the requirements of AWWA C540. Actuator output speed changes to be mechanically possible by simply removing the motor and changing the exposed or helical gear set ratio without further disassembly of the electric actuator.
   b. Ball or roller bearings to be used throughout.
   c. Actuators shall be oil or grease lubricated. Permanently lubricated devices are not acceptable. Lubrication shall be suitable for installation at any angle and in ambient temperatures of minus 20°F to plus 140°F.
   d. The drive shall include a lost motion device with hammer blow effect to allow the motor to reach full speed before engaging the valve load.
   e. Dry contact limit switches (gear limit switches, torque switches, or any and all other position switches) shall be rated minimum 2-amp at 120V AC. Provide the minimum number of dry contact limit switches called for on the control schematic shown on the PLANS. The state/development of each contact, throughout the travel limits of the valve, shall be as called for and/or demonstrated on the control schematic shown on the PLANS.
   f. Actuators shall be equipped with automatic double-acting torque switches. Torque switches shall operate during the complete valve cycle to protect the valve and actuator from excessive loads caused by obstructions in either direction of travel.
   g. Actuators shall be equipped with handwheels for manual operation and shall include an automatic clutch to positively disengage the handwheel at any time the drive motor control is energized. Handwheel operator shall be designed in such a way that failure of the motorized gearing shall not prevent hand operation of the valves.
   h. Actuators shall include a mechanical indicator that will provide continuous visual indication of valve position.

3. Motors:
   a. Motors shall be specifically designed for valve actuator service and shall be rated for high starting torque, low-starting current, full voltage starting, totally enclosed, non-ventilated construction.
   b. Motor is to be rated for continuous duty operation. When requirements of the individual valve specifications do not allow a continuous duty motor, provide a motor capable of a minimum of 1200 starts per hour. Fifteen minute duty cycle motors are not acceptable.
   c. Motor insulation for 480V motors shall be NEMA Class F, as a minimum at 50 degree F ambient temperature.
   d. With a line voltage ranging between 10 percent above to 10 percent below the rated voltage, the motor to develop full rated torque continuously without causing the thermal contact protective devices imbedded in the motor windings to trip or the starter overloads to drop-out.

e. All bearings to be of the ball type and thrust bearings to be provided where necessary. All bearings shall be provided with suitable seals to confine the lubricant and prevent the entrance of dirt and dust.

f. Motor conduit connections to be watertight and rated for temporary submergence. Motor construction shall incorporate the use of stator and rotor as independent components from the valve or operation such that the failure of either item does not require actuator disassembly or gearing replacement.

g. Modulating valves are required for some applications. Provide motor that is rated for modulation duty for up to 1200 starts per hour.

4. Controls:

a. General Description: Unless noted otherwise on PLANs (refer to following paragraph), terminal blocks, valve positioner, related interconnect wiring, etc., shall be an integral part of the actuator assembly and shall be provided with the actuator. Control voltage shall be 120-volt AC, unless noted otherwise on PLANs.

b. Some PLANS may show actuators where the starter, overloads, feeder breaker assembly, pilot lights, pilot devices, selector switches, pushbuttons, etc., are mounted remote from the actuator assembly.

c. Every effort has been made to reference a relevant control schematic for each valve actuator on the PLAN schedules. However the contractor is responsible for verifying that the equipment furnished accommodates the controls configuration as defined on all electrical and instrumentation drawings, prior to bidding the project.

d. Modulating Valves: The PLANS require several valves that modulate in response to a 4-20 mA signal and provide a 4-20 mA position indication. For these valves, provide feedback potentiometer and integral electronic positioner/comparator circuit to maintain valve position, AC motor with reversing starter, and controller capable of 1200 starts per hour and Duty cycle limit timer and adjustable band width to reduce actuator hunting. They are to operate with the following control description:

1) The actuator shall include a HAND/OFF/DCS switch or pushbutton and an OPEN/STOP/CLOSE switch or pushbutton.

2) In the HAND position, the actuator shall be controlled by the OPEN/ STOP/CLOSE switch. Motor shall drive the valve to fully OPEN or CLOSED position when the pushbutton is momentarily depressed. Motor shall stop in mid-travel when the stop button is depressed.

3) In the DCS position, the actuator shall position the valve in response to a 4-20 mA DC signal with 4 mA corresponding to FULLY CLOSED and 20 mA to FULL OPEN.

4) HAND/OFF/DCS and OPEN/STOP/CLOSE devices shall be integral with the actuator for actuator unless otherwise indicated.

5) Dry contact for remote indication of the DCS status of the selector switch.

6) Actuators shall include an integral position transmitter producing a 4-20 mA DC signal to continuously indicate the valve position. 4 mA shall correspond to the FULLY CLOSED position. The transmitter shall be capable of driving an external Load impedance of zero to 500 ohms.

7) Double-acting limit switches field adjusted to trip at any point between FULLY OPENED or FULLY CLOSED.

8) Double-acting torque switches to protect valve from excessive loads at any point between FULLY OPENED or FULLY CLOSED.

5. Operation:

a. Open-close service:

1) Operators shall operate automatically by remote signal specified and as indicated on the PLANS.

b. Modulating service:
1) Actuator controller: Microprocessor based and using proportional-integral derivative algorithm to calculate actuator response.
2) Controller shall compare 4-20mA direct-current analog command signal to analog feedback signal and move actuator accordingly.
3) Microprocessor-based controller shall control integrally mounted solid state reversing starter.

c. Where indicated on the PLANS, provide 4-20mA direct-current analog output signal for continuous remote monitoring of position.

d. Controller system: Rated for continuous duty.

e. Operation: As specified.

G. Tagging: Provide per Section 15075 “Mechanical Identification”.

H. Limit Switches for Manual Valves:
1. Provide for the manual valves as listed on Valve Schedule in Drawings.
2. Factory installed limit switches to be installed on the valve by valve manufacturer.
3. Provide two SPDT switches one for the valves fully OPEN and one for fully CLOSED position. Provide each assembly with two 5-amp, 125V AC switches. Switches shall be actuated by a position indicator mechanism.
4. Valve shall also be provided with local position indication.
5. Limit switches shall be provided standard with NEMA 4X enclosure. Where Class I, Group C and D, Division I and II areas are indicated on the schedule provide suitable enclosures.
6. Limit switches shall be valve manufacturer standard.

I. Extension Bonnet for Valve Operator: Complete with stem and accessories for valve and operator.
1. Manufacturers and Products:
a. Pratt.
b. Allis-Chalmers.

J. Floor Stand and Extension Stem:
1. Nonrising, indicating type.
2. Complete with stem, coupling, handwheel, stem guide brackets, and yoke attachment.
3. Stem Guide: Space such that stem L/R ratio does not exceed 200.
4. Anchor Bolts: Type 304 SST.
5. Manufacturers and Products:
a. Clow; Figure F-5505-T.
b. Troy Valve

K. Floor Box and Stem:
1. Plain type, for support of nonrising type stem.
2. Complete with stem, operating nut, and stem guide brackets.
3. Stem Guide: Space such that stem L/R ratio does not exceed 200, capable of being mounted with wall bracket; adjustable in two directions.
4. Anchor Bolts: Type 304 SST.
5. Manufacturers and Products:
a. Troy Valve
b. Clow; No. F5695-T.

L. Chain Wheel and Guide:
1. Handwheel direct-mount type.
2. Complete with chain.

3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
   a. Clow Corp.; Figure F-5680.
   c. DeZurik Corp.; Series G.

M. Cast Iron Valve Box: Provide per details on PLANS.

PART 3 - EXECUTION

3.01 GENERAL

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by CONTRACTOR.
   2. Where such additional valves are required as a result of a substitution or change initiated by CONTRACTOR.

3.02 PREPARATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine the face-to-face dimensions of flanged valves after flanged valves are selected.

B. Fabricate piping to lengths taking into account the dimensions of valves.

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Flange Ends:
   1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
   2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.
   3. Orient all bolts and nuts in same direction to provide an orderly installation.
   4. Provide threaded bolts or threaded rod of size, length and materials as recommended by the valve manufacturer where required to connect flange piping or fittings to valve. Threaded rods or studs shall be installed in the valve before connecting the valve to pipe or fitting where required to install the valve. (Example: Bolts on the inside of a 90-bend when bolted to a plug valve.)

B. Threaded Ends:
   1. Clean threads by wire brushing or swabbing.
   2. Apply joint compound or Teflon tape on external (male) threads to prevent forcing compound into valve seat area.

C. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

D. Valve Orientation:

1. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
2. Install operating stem horizontal in horizontal runs of pipe having centerline elevations between 4 feet 6 inches and 6 feet 9 inches above finish floor, unless otherwise shown.
3. Orient butterfly valve shaft so that unbalanced flows or eddies are equally divided to each half of the disc, i.e., shaft is in the plane of rotation of the eddy.
4. If no plug valve seat position is shown, locate as follows:
    a. Horizontal Flow: The flow shall produce an “unseating” pressure, and the plug shall open into the top half of valve.
    b. Vertical Flow: Install seat in the highest portion of the valve.

E. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

F. Extension Stem for Operator: Where the depth of the valve is such that its centerline is more than 3 feet below grade, furnish an operating extension stem with 2-inch operating nut to bring the operating nut to a point 6 inches below the surface of the ground and/or box cover.

G. Torque Tube: Where operator for quarter-turn valve is located on floor stand, furnish extension stem torque tube of a type properly sized for maximum torque capacity of the valve.

H. Valve Box and Stem: Install floor boxes in concrete with lid flush to floor. Place top of valve boxes flush with finished grade or as otherwise indicated on the PLANS. Steel extension stem length shall locate operating nut in valve box.

I. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finished floor. Where chains hang in normally traveled areas, use appropriate “L” type tie-back anchors.

3.04 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other, in both directions for two-way valve and applications.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for any discrepancies with manufacturer’s data.

E. Set, verify, and record set pressures for all relief and regulating valves.

F. Automatic valve to be tested in conjunction with control system testing.

G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 MANUFACTURER’S FIELD SERVICES

A. Provide manufacturer’s field services per Section 01445, “Manufacturers Field Services”.

B. Manufacturer's Services and Certificate of Proper Installation: Provide Manufacturer's Services and Manufacturer's Certificate of Proper Installation in conformance with the requirements of Section 01445, "Manufacturers Field Services". Manufacturer's representation shall provide supervision of equipment installations, field inspection of equipment before startup and the executed copies Manufacturers Services and Certificate of Proper Installation.

C. Unless otherwise specified, provide a minimum of 1/2 person-day and 1 trip for CONTRACTOR assistance for installation assistance, startup assistance, functional and/or performance testing, and completion of Manufacturer's Certificate of Proper Installation, as specified in Section 01445, "Manufacturers Field Services".

D. Provide a minimum of 1/2 person-day and 1 trip for OWNER training at OWNER's request, as specified in Section 01445, "Manufacturers Field Services".

E. The person days and trips provided by the manufacturer shall be provided for each valve type and operator that requires routine maintenance beyond scheduled exercising of the unit.

3.04 - 3.09 (NOT USED)

3.10 SCHEDULES

A. Requirements relative to this Section are shown on Valve Schedule located in the PLANS.

B. Geared operators: Provide geared operators for following valves:
1. Manual Valves, multi turn, larger than 6 inches, nominal size, on liquid service.

C. Handwheel operators: Provide handwheel operators for valves mounted 6 feet or less above floors.

D. Chain wheel operators: Provide chain wheel operators for valves mounted more than 6 feet to center line above floors.

3.11 MEASUREMENT AND PAYMENT

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 15111

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Metal body ball valves and plastic body ball valves.

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 extend referenced. The publications are referred to in the text by basic designations only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

1. ASME B16.1 Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
2.
3. ASME B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C507 Standard for Ball Valves 6 Inch Through 48 Inch.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 48 Standard Specification for Gray Iron Castings.

ASTM A 216 Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.

ASTM A 276 Standard Specification for Stainless Steel Bars and Shapes

ASTM A 351 Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

ASTM B 584 Standard Specification for Copper Alloy Sand Castings for GeneralApplications

1.04 DEFINITIONS (NOT USED)

1.05 DESIGN AND PERFORMANCE CRITERIA

A. General: Unless otherwise indicated on the Drawings use:
   1. Metal body ball valves on metallic pipelines.
   2. Plastic body ball valves on plastic pipelines.

B. Do not use metal body ball valves in chemical systems.

1.06 SUBMITTALS

A. Submit the following shop drawing and product data in accordance with Specification Sections 01300 “Submittals”, Specification Section 01730 “Operation and Maintenance Data” and Specification Section 15100 “Valves”
   1. Product data.
   2. Certificates:
      a. Metal body ball valves: 6 inches and larger only. Submit affidavit of compliance in accordance with AWWA C507.
   3. Operation and maintenance data.

1.07 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 BALL VALVE, 2 INCH AND SMALLER FOR GENERAL WATER AND AIR SERVICE

A. Manufacturers and Products:
   1. Apollo; 82-100-01 Series.
   2. Nibco, Inc.; T-595-Y.

B. All-bronze, three-piece body type, threaded ends, full bore ports, Teflon seat, blowout-proof stem, hand lever operator, rated 150 psi SWP, 400-pound WOG minimum.

2.02 STAINLESS STEEL BALL VALVE, 2 INCH AND SMALLER (NOT USED)

2.03 STAINLESS STEEL BALL VALVE, 3 INCH AND SMALLER (NOT USED)

2.04 METAL BODY BALL VALVES, 6 INCH IN SIZE AND LARGER (NOT USED)

2.05 METAL BODY BALL VALVES, LESS THAN 6 INCH SIZE

A. Manufacturers: One of the following, or equal:
   1. Apollo Valves as manufactured by Conbraco Industries, Inc.
   2. NIBCO, Inc.
   3. Metso Automation/Jamesbury.

B. General:
   1. Type: Non-lubricated, full port and capable of sealing in either direction, 2 or 3 piece body design.
   2. End connections:
      a. Threaded or solder ends for sizes 3-inch and smaller.
      b. Class 150 flanged for sizes larger than 3 inch.
      c. Flanges: In accordance with ASME B16.1 standards.
   3. Stem packing: Manually adjustable while valve is under pressure.
   4. Shafts:
      a. Rigidly connected to the ball by a positive means.
      b. Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
   5. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
   6. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.

C. Materials:
   1. Valves in copper lines: Bronze body ASTM B584-C84400, Brass ball ASTM B16
   2. Valves in steel and ductile iron piping: Ductile iron or cast steel body, 316 Stainless Steel ASTM A 276 ball, unless otherwise noted on PLANS.
   3. Valves in stainless steel piping: Stainless steel body A351-CF8M, 316 Stainless Steel ball ASTM A 276.
   4. Seats: PTFE (Teflon).
   5. Stem seals: PTFE or Viton.

6. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
7. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) must be of fire safe design.

2.06 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:
1. Asahi America.
2. Plast-O-Matic Valves, Inc.

B. General:
1. Type: Non-lubricated and capable of sealing in either flow direction.
2. End connections: True union; solvent or heat welded to piping.
3. Operator handle: Lever.

C. Materials:
1. Body: Polyvinyl chloride (PVC).
2. Ball: Polyvinyl chloride (PVC).
3. Seats: PTFE (Teflon).
4. O-rings: FKM (Viton) or EPDM.

2.07 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

3.02 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15112

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Scope: Furnish and install butterfly valves for water as shown on PLANS and as specified herein.

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B16.1 1989 Cast Iron Pipe Flanges and Flanged Fittings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A48 1994 Standard Specification for Gray Iron Castings

ASTM 126 1993 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C504 1987 Rubber-Seated Butterfly Valves

1.04 - 1.05 (NOT USED

1.06 SUBMITTALS

A. Submit the following shop drawing and product data in accordance with Specification Sections 01300 “Submittals”, Specification Section 01730 “Operation and Maintenance Data” and Specification Section 15100 “Valves and Operators”

1. Shop Drawings: For all valves and all valves with geared, cylinder, or electric operators. Include size, class, operator, orientation, valve and operator dimensions, and materials by ASTM designations.
2. Manuals: Operation and maintenance manuals to include special maintenance and adjustment instructions and expanded or detailed drawings with parts descriptions, numbers, and material specifications.
3. Certification of factory testing specified in Section 1.07 D.

1.07 QUALITY ASSURANCE

A. Valve and operator to conform fully with requirements of AWWA C504 with limitations included herein.

B. Valve, operator, and accessories to be furnished as a complete unit by valve manufacturer.

C. Standardization: All valves and operators to be of same manufacturer.

D. Testing: All valves to be hydrostatic and leak tested in accordance with AWWA C-504. Hydrostatic test inside of valve body at minimum test pressure of 1.5 times the rated working pressure for five minutes.

1.08 - 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 BUTTERFLY VALVES – LIQUID SERVICE

A. Manufacturers: One of the following or equal:
1. DeZurik.
2. Pratt.
3. Val-Matic.
4. GA Industries.

B. General: Specified as AWWA C504 to be in compliance with AWWA C504 for Rubber Seated Butterfly Valves and following requirements:
1. Suitable for infrequent operations after periods of inactivity.
2. Elastomer seats bonded or vulcanized to body shall have adhesive integrity of bond between seat and body assured by testing with minimum 75-pound pull in accordance with ASTM D429, Method B.
3. Bubble-tight with rated pressure applied from either side.
4. No travel stops for the disc on interior of the body.
5. Self-adjusting V-type or O-ring shaft seals. Seal shall be replaceable without disassembly of valve.
6. Isolate metal-to-metal thrust bearing surfaces from flowstream.
7. Buried valves shall be designed for buried service.
8. Provide valves that conform to NSF Standard 61.
9. Class 150B valves except as specified or indicated.
10. Service: Secondary treated wastewater.

C. Valve Body: ASTM A126 Class B cast iron or ductile iron.
1. Exposed or submerged service: Flanged short body valve.
2. Buried service: Mechanical joint body.
3. Wafer, lug wafer or tapped wafer valves may be used only as specified or indicated.

D. Disc and Valve Seats:
1. Disc: Ductile Iron.
2. Wastewater or Sludge Service: Molded neoprene, Buna-N or other synthetic elastomer resistant to oil and grease.
3. Provide seat mounted on disc or in body.
4. Provide seats offset from shaft and field replaceable for all valves 24-inch and larger.
5. Provide seats mounted on disc, mechanically fastened to disc with Type 316 stainless steel hex head screws. Provide rubber seat reinforced with stainless steel retaining ring. Seats vulcanized or bonded to the disc are not acceptable.

E. Mating surfaces for valves with seat on disc: Type 316 stainless steel.
   1. Provide mating surface mechanically retained in body and sealed with O-ring.

F. For valves with seats mounted on body provide the seats clamped or mechanically secured with Type 316 stainless steel fasteners.
   1. Mating surfaces for valve with seat in body: Type 316 stainless steel or plasma applied nickel-chromium material containing 80 percent nickel, 20 percent chrome.
   2. Plated or sprayed on mating surface material not acceptable.

G. Seat Placement:
   1. If seat on disc provide disc of ASTM A126 Class B cast iron or ductile iron.
   2. If seat in body, provide disc of ASTM A126 Class B cast iron, ductile iron or Type 316 stainless steel. Type 316 Stainless steel edge on cast or ductile-iron discs secured with Type 316 stainless steel threaded fasteners, heat shrunk on disc, a welded-on overlay, or a plasma applied nickel-chrome material.

H. Shaft: Type 316 stainless steel. Either one piece extending completely through disc or stub shafts inserted into valve disc stubs.

I. Shaft seal of the split-V type or O-ring type. Seal replaceable without disassembly of valve.

2.02 BUTTERFLY VALVE – AERATION SERVICE (NOT USED)

2.03 BUTTERFLY VALVE – TRIPLE OFFSET METAL SEATED (NOT USED)

2.04 BUTTERFLY VALVE – NON METALLIC (NOT USED)

2.05 BUTTERFLY VALVE – CHEMICAL SEVICE, LINED (NOT USED)

2.06 BUTTERFLY VALVE – HIGH PERFORMANCE (NOT USED)

2.07 BUTTERFLY VALVE – DIGESTER GAS SERVICE (NOT USED)

PART 3 EXECUTION

3.01 - 3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Installation:
   1. Mount as shown or for maximum operator convenience.
   2. Pressure test with piping system. Operate satisfactorily through at least three cycles.

B. Operators
   1. Position indicator required.
   2. Counter-clockwise to open.
   3. Factory mounted and tested.
   4. For buried gear operator valves, protect valves with a minimum 8 mil polyethylene film brought up and permanently taped to the valve box. Include extension stem, 2-inch square operating nut, and cast iron valve box for each buried valve. Provide locking feature if called out on PLANS.
   5. Gear to be grease packed, totally enclosed for buried service.

3.04 REPAIR/RESTORATION (NOT USED)

3.05 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Furnish services of qualified factory trained technical representative to check installation and assist CONTRACTOR in making adjustments to mechanical stop-limiting devices.

3.06 - 3.10 (NOT USED)

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 15114

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Center guide (silent) check valves, Swing check valves, Cushioned swing check valves, and Plastic ball check valves.

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 extend referenced. The publications are referred to in the text by basic designations only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

C508	Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch (50-mm Through 600-mm) NPS

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

B16.1	Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A 276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A 582	Standard Specification for Free-Machining Stainless Steel Bars
ASTM B 62	Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 582	Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip
ASTM B 584	Standard Specification for Copper Alloy Sand Castings for General Applications

1.04 DEFINITIONS (NOT USED)

1.05 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Check valves: When not otherwise indicated on the Drawings, provide check valves suitable for service as follows:
      a. In either horizontal or vertical position.
      b. Under pressures equal and less than 150 pounds per square inch gauge.

1.06 SUBMITTALS

A. Submit the following shop drawing and product data in accordance with Specification Sections 01300 “Submittals”, Specification Section 01730 “Operation and Maintenance Data” and Specification Section 15100 “Valves and Operators”
   1. Product data.
   2. Certificates:
      a. General purpose AWWA check valves:
         1) Affidavit of compliance attesting valves provided comply with all provisions in accordance with AWWA C508.
   3. Operation and maintenance data.

1.07 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 CENTER GUIDE (SILENT) CHECK VALVES

A. Manufacturers: One of the following or equal:
   1. APCO, Model Number 600.
   2. Or approved equal.

B. Valve design:
   1. Center guided at both ends, stainless steel spring-loaded plug.
   2. Globe style body, with flow area through the body equal or greater than the cross sectional area of the equivalent pipe size.
   3. Replaceable seat and plug.
   4. Shaft guide bushing.
   5. Non-slam, guaranteed silent shut-off operation.
   6. Flanged body.

C. Materials:
   1. Body: Cast iron, ASTM A 126 Grade B.
   2. Plug and seat: Bronze, ASTM B 584 C83600 or ASTM B62
   3. Spring: Stainless steel, ASTM A 276 Type 316.
   4. Shaft and bushing: Bronze, ASTM B 584 C83600.

2.02 SWING CHECK VALVES (NOT USED)

A. Valves 1/4 inch through 3 inch:
   1. Manufacturers: One of the following or equal:
      a. Crane Valve Company, Number 36.
      b. Lunkenheimer Company, Figure 554Y.
   2. Valve design:
      a. Threaded joints.
      b. Y-pattern body with integral seat.
      c. Hinged disc.
      d. Access to valve seat for regrinding without disassembly of piping.
   3. Materials:
      a. Body, cap, hinge, and disc: Bronze.

B. Valves 4 inch through 24 inch:
   1. Manufacturers: One of the following or equal:
      a. Kennedy, Figure 106LW.
      b. Mueller Company, Model A-2600.
      c. M&H, Model 159.
   2. Valve design:
      a. In accordance with AWWA C508.
      b. Constructed to permit top entry and removal of internal components without removing the valve.

c. Equipped with outside lever and weight.

3. Materials:
   a. Body: Cast iron, ASTM A 126 Class B.
   b. Disc:
      1) 4-inch valves: Bronze.
      2) 6 inches and larger valves: Bronze faced.
   c. Hinge pins: Stainless steel.

C. Valve 24 inch and 30 inch with dual external lever and spring.

1. Manufacturers: One of the following or equal:
   a. GA Industries, Figure 230-D.
   b. APCO, series 6000CLS.
2. Valve design:
   a. In accordance with AWWA C508.
   b. Constructed to permit top entry and removal of internal components without removing the valve.
   c. Equipped with dual external lever & spring.
   d. Upon loss of power (surge condition) the valve shall be able to close in no more than 3 seconds with no slamming. CONTRACTOR to coordinate with surge tank supplier for adjustment of check valve closing time to avoid slamming.
3. Materials:
   a. Body: Cast iron, ASTM A 126 Class B with integral flanges drilled to ANSI B16.1 Class 250
   b. Valve Disc and Disc arm: Ductile Iron, ASTM A536.
   c. Seat:
      1) Body: replaceable bronze seat
      2) Disc: resilient seat ring, replaceable.
   d. Shaft: Stainless Steel type 18-8 or 17-4PH, supported at each end by heavy bronze bushing.

2.03 CUSHIONED SWING CHECK VALVES (NOT USED)

A. Manufacturers: One of the following or equal:
1. GA Industries – Series 250
2. APCO, Air Cushioned Swing-Check, Series 6000.

B. Valve design:
1. Counter-weighted.
2. Rubber seated and drip tight.
3. Totally enclosed pneumatic dampening chambers with adjustment for closing speed.

C. Materials:
1. Valve body, cover, and disc: Cast iron, ASTM A 126, Class B.
2. Disc seat: Buna N.
3. Shaft: Stainless steel.
4. Cushion cylinder: Corrosion resistant metal.
5. Disc ring seat: Bronze.
6. Seat pins and lock screws: Stainless steel

2.04 RUBBER FLAPPER CHECK VALVES

A. Manufacturers: One of the following or equal:
1. Val-Matic
2. DeZurik APCO
3. Crispin

B. Provide valves with a full pipe size flow area.

C. Provide valves 4-inch and larger capable of passing a 3-inch sphere.

D. Provide a threaded connection with bronze plug on cover and on the bottom of the valve.

E. Provide hold open device to allow easy access for back-flushing and draining.

F. Provide valve with an externally adjustable spring return to accelerate flapper closure, without the need to remove the cover from the valve or to remove the valve from service.

G. Working Pressure:
1. 2-inch through 24-inch: 250 psi
2. 30-inch and 36-inch: 150 psi

H. Ends: Flanged ANSI B16.1, Class 150.

I. Provide seating surface at a 45 degree angle such that the flapper travels a maximum of 35 degrees from full closed to full open position.

J. Provide valve with cover designed for removal of the valve internals without removing the valve from the pipeline.

K. Position Indicator:
1. Provide a mechanical indicator to provide disc position for valves 4-inch and larger.
2. Provide the indication with continuous contact with the disc.

L. Materials:
1. Body and Cover: Ductile Iron ASTM A536 Grade 65-42-12.
2. Rubber Flapper: Buna N 70 Durometer ASTM 2000-BG encapsulating an ASTM A36 steel plate.
3. Hinge Pin: AISI 1018.

PART 3 EXECUTION

3.01 – 3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Install valves in accordance with manufacturer's instructions and contract requirements.

B. Flapper type check valves:
1. Install with proper orientation of flow direction arrow on valve body.
2. When installed in horizontal pipelines, mount with shaft on vertical locations.
3. When mounted in a vertical pipeline, directly downstream of an elbow, mount with the shaft perpendicular to the outermost portion of the elbow.
4. Mount on downstream side of discharge silencer when used on positive displacement and centrifugal blowers.

3.04 – 3.05 (NOT USED)

3.06 ADJUSTING

A. Adjust cushioned swing check valves in the field by means of external adjustment devices to minimize pressure surges.

B. Adjust weight or spring on swing check valves to affect proper closing action on equipment shutdown.

3.07 – 3.10 (NOT USED)

3.11 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 15115

GATE, GLOBE, AND ANGLE VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Gate, globe, angle, plug disc and plain hose valves, and yard hydrants.

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.

American Society of Mechanical Engineers (AMSE)

American Water Works Association (AWWA)

C 509	Resilient-Seated Gate Valves for Water Supply Service (Includes Addendum C509a-95).
C515	Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Services.
C 550	Protective Interior Coatings for Valves and Hydrants.
C110/A21.1	Ductile-Iron and Gray-Iron Fittings
C500	Metal-Seated Gate Valves for Water Supply Service
C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

ASTM International (ASTM)

B 98	Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
D1784	Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
A536	Standard Specification for Ductile Iron Castings

1.04 – 1.05 NOT USED

1.06 SUBMITTALS

A. Submit the following shop drawing and product data in accordance with Specification Sections 01300 “Submittals”, Specification Section 01730 “Operation and Maintenance Data” and Specification Section 15100 “Valves and Operators”
   1. Product Data.
   2. Certificates:
      a. General purpose AWWA gate valves.

1) Proof-of-Design Tests: Certified statement that proof-of-design tests were performed and all requirements were successfully met.
2) Affidavit of compliance attesting valves provided in accordance with all provisions of AWWA C509, C515.

b. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of valves and hydrants comply in accordance with all provisions of AWWA C550.

3. Operation and Maintenance Data.

1.07 QUALITY ASSURANCE

A. Motorized operators for gates and valves: The product of a single supplier for all valves on Project.

B. Valve manufacturer to provide limit switches with valves.

C. Actuator/operator manufacturer shall coordinate with the valve manufacturer and submit calculations showing the maximum and normal operating torques for the valves and operators supplied.

1.08 DELIVERY, STORAGE AND HANDLING

A. Shipping: Deliver to the job site in manufacturer's original containers.

B. Handling and Unloading: After wet operations in building are completed.

C. Storage and Protection:
1. Store materials in original, unopened containers in compliance with manufacturer's printed instructions.
2. Keep materials dry until ready for use. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.
3. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

1.09 – 1.11 NOT USED

PART 2 PRODUCTS

2.01 GATE VALVES

A. Resilient Seated Gate Valves 3 inches in size and larger:
1. Ductile Iron body, resilient seat, bronze mounted, rated 200 psi cold water, full port, fusion epoxy-coated inside and outside, ASTM A536.
2. Valve shall meet or exceed applicable requirements of AWWA C515
3. Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
4. Bronze non-rising stem in accordance with AWWA C515.
5. Bolting material to be 304 Stainless Steel.
6. Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.
7. Valve shall be NSF Standard 61 certified.
8. Manufacturers: One of the following or equal:
   a. American Flow Control (4”-12”);
   b. Clow R/W (4”-12”);
   c. Mueller Co Series A-2360;
   d. American AVK Co. Series 65 (4”-12”)

B. Double Disc Gate Valve, 3-Inch to 48-Inch (NOT USED)

C. Gate Valve, 16-Inch and Larger, AWWA C500 Valves for Buried Water Service (NOT USED)

D. Resilient Seated Gate Valve, 3-Inch to 20-Inch, for Buried Service (NOT USED)

E. Knife Gate Valve, 24-Inch and Smaller (NOT USED)

2.02 GLOBE AND ANGLE VALVES (NOT USED)

2.03 NEEDLE VALVES (NOT USED)

2.04 HOSE VALVES AND YARD HYDRANTS

A. Hose valves:
1. Manufacturers:
   a. Globe threaded valve: One of the following or equal:
      1) Crane, No. 7TF.
      2) Stockham, Figure No. B22T.
   b. Angle threaded valve: One of the following or equal:
      1) Crane, No. 17TF.
      2) Stockham, Figure No. B222T.
2. Design:
   a. Valve: Globe or angle valve with threaded ends size 1/8 inch to 3 inches in diameter, size as indicated on the PLANS.
   b. Disc: Renewable, made of Teflon or Buna-N.
   c. Threaded ends, rated for a pressure of 200 pounds per square inch.
   d. All-bronze, inside screw, rising stem, outlet of cast brass NHT by NPT, male by male, nipple adapted with hexagonal wrench feature.

B. Freezeless yard hydrant:
1. Manufacturers: One of the following or equal:
   a. Josam, Series 71700.
   b. Zurn, Z-1385.

PART 3 EXECUTION

3.01 - 3.02 NOT USED

3.03 ERECTION/INSTALLATION/APPLICATION INSTRUCTION

A. Install valves in accordance with manufacturer's instructions.

B. Locate valve boxes where indicated on the PLANS.

C. Install valves as specified and in accordance with manufacturer’s instructions.

D. Mount yard hydrants on iron pipe risers minimum 1-inch nominal diameter or size indicated on the PLANS.

3.04 – 3.10 NOT USED

3.11 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 15116

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Lubricated plug valves.

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 designations only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C517 Resilient-Seated Cast Iron Eccentric Plug Valves

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 126 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

ASTM A 536 Standard Specification for Ductile Iron Castings

1.04 –1.05 (NOT USED)

1.06 SUBMITTALS

A. Submit the following shop drawing and product data in accordance with Specification Sections 01300 “Submittals”, Specification Section 01730 “Operation and Maintenance Data” and Specification Section 15100 “Valves and Operators”
   1. Product data.
   2. Certificates:
      a. General purpose AWWA plug valves:
         1) Affidavit of compliance attesting valves provided comply with all provisions in accordance with AWWA C517.
   3. Operation and maintenance data.

1.07 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 ECCENTRIC PLUG VALVE, 4-INCH TO 48-INCH

A. Manufacturers and Products:
   1. DeZurik; Style PEC
   2. Milliken; Millcentric Series 600.
   3. Val-Matic

B. Type: Nonlubricated, eccentric.

C. Body Working Pressure:

1. Cast Iron, ASTM A126 Class B or Ductile Iron, ASTM A536, Grade 64-45-12.
    a. Valves 4-inch through 12-inch: 175 psi.
    b. Valves 14-inch and larger: 150 psi.
    c. Drip-tight shutoff with pressure from either direction.

D. Ends:
1. Grooved: ANSI/AWWA C606 for ductile iron valves.
2. Flanged: ANSI B16.1 125 pound for cast iron valves.
3. Flanged: B16.5 150 pound for carbon steel and stainless steel valves.
4. Buried Valves: Mechanical joint.

E. Valve Ports:
1. Provide round or rectangular ported valves.
2. Not less than 80 percent of pipe area.

F. Valve Seats;
1. Coat plug with seat material specified. Bolted systems are not acceptable.
    a. Seat Material:
        1) Neoprene or Buna-N synthetic rubber.
2. Provide valves with one piece coated plugs with mating seats of 90 percent, minimum, pure nickel 1/8-inch welded into the body of valves.
3. Provide valves with seats clamped to valve with mating seat of 90 percent, minimum, pure nickel welded to the valve body.

G. Upper and Lower Plug Journal Bearings:
1. Removable, permanently lubricated stainless steel bushings for valves 20-inch and smaller.
2. Bronze bearings with Type 316 stainless steel bushings for valves 24-inch and larger.
3. Provide grit seals for upper and lower plug shafts for all valves.

H. Steam Seals:
1. Adjustable multiple V-rings, U-cups, or O-rings of nitrite rubber, grit seal on stem.
2. Replaceable and adjustable without valve disassembly.
3. Provide valves with two sets of packing rated for vacuum service for all pump suction isolation service and for services where a vacuum is specified and indicated.

I. Operators for Valves 4-inch and larger:
1. Manually Operators:
    a. Gear operated with handwheels, levers are not acceptable.
    b. Provide gear operators rated for bi-directional shutoff at the valve working pressure rating as specified herein.
    c. Gear operators: Totally enclosed worm gear, traveling nut type is not acceptable. Provide permanently lubrication, watertight and dustproof, with adjustable open and closed stops and plug position indicator.
    d. Provide all work gears designed and certified to withstand input loads up to 300-feet-pounds minimum at the stops without damage.
    e. Buried or submerged valves: Provide watertight gear operator with handwheel operated floorstand as shown. Gear operator to be totally enclosed and gasketed with Type 316 stainless steel hardware.
    f. Chainwheels: Provide where required as specified herein.
    g. Where indicated provide Type 316 stainless steel stem extension to operating floor elevation as shown and provide the bevel gear operator with a fabricated steel floorstand and handwheel.
2. Electric Motor Actuators: Provide where indicated and provide in accordance with Section 15100.

2.02 THREE-WAY, NONLUBRICATED, TAPERED PLUG VALVE, 3-INCH TO 16-INCH (NOT USED)

2.03 INVERTED TAPERED PLUG VALVE, 1-INCH TO 4-INCH (NOT USED)

2.04 INVERTED TAPERED PLUG VALVE, 4-INCH TO 30-INCH (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Lubrication: Lubricate plug valves and fill extended lubricant pipes with lubricant suitable for service intended.

3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Install valves as specified in Section 15100 and the manufacturer's instructions.

B. Install valves so that in the closed position the pressure in the pipeline applies a seating head on the valves.

C. Install valves so that in the open position the plug is located in the top half of the valve body.

3.04 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15118

FLOW CONTROL, PRESSURE REDUCING AND PRESSURE RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure reducing and pressure relief valves for water, air, sludge and chemical service.

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 extend referenced. The publications are referred to in the text by basic designations only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASTM B16.42 Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 48 Standard Specification for Gray Iron Castings.

ASTM A 126 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

ASTM A 536 Standard Specification for Ductile Iron Castings.

1.04 - 1.05 (NOT USED)

1.06 SUBMITTALS

A. Submit the following information as specified in Sections 01300 “Submittals” and Specification Section 15110 “Valves”:
   1. Product data.
   2. Operation and maintenance data.

1.07 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 WATER PRESSURE REDUCING VALVES

A. Water pressure reducing valves, 3 inches and smaller:
   1. Manufacturers: One of the following or equal:
      a. Watts Regulator, Series 223.
      b. Wilkins, 500 Series.
   2. Direct operated, spring controlled, single seat type pressure reducing valve.
   3. Provide separate strainer upstream of valve when indicated on PLANS.
   4. NPT threaded ends.
   5. Materials:
      a. Body and spring cover: Bronze.

b. Valve spring: Stainless steel.
c. Seat: Stainless steel, replaceable.
d. Diaphragm: EPDM.
e. Disk: EPDM.

B. Water pressure reducing valves, 2 inches and larger:
1. Manufacturers: One of the following, or equal:
a. Cla-Val Model 90-01.
b. Watts ACV Series 115.
c. Bermad Model 720
2. Design:
a. Provide valve equipped with anti-cavitation device if valve may be subjected to cavitation. Valve manufacturer to determine based on installation conditions if anti-cavitation devices are required.
b. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
c. Rated for 125 pounds per square inch gauge.
d. Pilot line: Equipped with a strainer.
e. Flanges: 150 pound rating, conforming to ASME B16.42.
3. Materials:
a. Body and cover: Cast iron ASTM A 48 or Ductile Iron ASTM A 536.
b. Valve trim: Bronze.
c. Pilot control: Cast bronze with Series 303 stainless steel trim.
d. Diaphragm: Nylon reinforced Buna N.

2.02 WATER PRESSURE RELIEF/ PRESSURE SUSTAINING VALVES

A. Water pressure relief valves:
1. Manufacturers: One of the following, or equal:
a. Cla-Val Model 50-01.
b. Watts ACV Series 116.
c. Bermad Model 730.
2. Design:
a. Provide valve equipped with anti-cavitation device if valve may be subjected to cavitation. Valve manufacturer to determine based on installation conditions if anti-cavitation devices are required.
b. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
c. Rated for 125 pounds per square inch gauge.
d. Pilot line: Equipped with a strainer.
e. End connections:
1) 2 1/2 inch and smaller: Screwed.
2) 3 inch and larger: 150 pound rated flanges conforming to ASME B16.42.
3. Materials:
a. Valves 1-inch and larger
1) Body and cover: Cast iron ASTM A 48 or Ductile Iron ASTM A 536.
2) Valve trim: Bronze.
3) Pilot control: Cast bronze with Series 303 stainless steel trim.
4) Diaphragm: Nylon reinforced Buna N.
b. Valves 1-inch and smaller
1) Body and cover: bronze
2) Diaphram: bronze
3) Seat packing: polyurethane
4) Pilot stem: bronze

5) O-ring: Buna-N

2.03 SURGE ANTICIPATING VALVES (NOT USED)

2.04 FLOW CONTROL VALVES

A. Flow control valves, 2 inches and larger:
   1. Manufacturers: One of the following or equal:
      a. Cla-Val Model 40-01.
      b. Bermad Model 770-U.
   2. Design:
      a. Provide valve equipped with anti-cavitation device if valve may be subjected to cavitation. Valve manufacturer to determine based on installation conditions if anti-cavitation devices are required.
      b. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
      c. Provide an orifice plate with holder for flow rate control.
      d. Rated for 125 pounds per square inch gauge.
      e. Pilot line: Equipped with a strainer.
      f. Flanges: 150 pound rating, conforming to ASME B16.42.
   3. Materials:
      a. Body and cover: Cast iron ASTM A 48 or Ductile Iron ASTM A 536.
      b. Valve trim: Bronze.
      c. Pilot control: Cast bronze with Series 303 stainless steel trim.
      d. Diaphragm: Nylon reinforced Buna N.

PART 3 EXECUTION

3.01 GENERAL

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

3.02 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15119

AIR AND VACUUM RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Air release valves, air and vacuum valves, and air vents.

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. AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
ASME B16.5	Pipe Flanges and Flanged Fittings: NPS 1/2 through 24

B. AMERICAN SOCIETY FOR TESTING MATERIALS (ASTM)

ASTM A 126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A 240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A 270	Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing
ASTM B 584	Standard Specification for Copper Alloy Sand Castings for General Applications

1.04 – 1.05 (NOT USED)

1.06 SUBMITTALS

A. Submit the following shop drawing and product data in accordance with Specification Sections 01300 “Submittals”, Specification Section 01730 “Operation and Maintenance Data” and Specification Section 15100 “Valves and Operators”
   1. Product data.
   2. Operation and maintenance data.

1.07 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 AIR RELEASE VALVES, WATER SERVICE

A. Manufacturers: One of the following or equal:
   1. GA Industries
      a. Figure 905 – ½” and ¾”

b. Figure 920 – 1”

2. DeZurik APCO
   a. Series 50 – ½” and ¾”
   b. Series 200 – 1”
3. Multiplex Manufacturing Company, Crispin PL Series.

B. Design:
1. Pressure rating: 150 pounds per square inch gauge, unless otherwise noted on the PLANS.
2. Inlet: Screwed, 1-inch.
3. Orifice size: 3/32 inch diameter for 1/2” and 3/4” valves and 3/16 inch diameter for 1” valve unless otherwise noted on the PLANS.
4. Install isolation valve between parent pipe and air release valve.

C. Materials:
1. Valve body: Cast iron.
2. Float and internal trim: Type 316 stainless steel.
3. Seat or valve plunger: Buna-N.

2.02 AIR AND VACUUM VALVES, WATER SERVICE (NOT USED)

2.03 AIR AND VACUUM SLOW CLOSING VALVES (NOT USED)

2.04 COMBINATION AIR VALVES, WATER SERVICE (NOT USED)

2.05 AIR RELEASE VALVES, SEWAGE SERVICE

A. Manufacturers:
1. GA Industries Fig. 925
2. DeZurik APCO Series 400 SARV.
3. Multiplex Manufacturing Company, Crispin Series S.
4. The City of Austin Water and Wastewater Utility Standard Products Lists (SPL) are considered to form a part of these Specifications. Contractors may, when appropriate, elect to use products from the SPL; however, submittal to the Engineer/Architect (E/A) is still required. If the Contractor elects to use any materials from these lists, each product shall be completely and clearly identified by its corresponding SPL number when making the product submittal. This will expedite the review process in which the E/A, and, if necessary, the Water and Wastewater Utility Standard Products Committee, decide whether the products meet the Contract requirements and the specific use foreseen by the E/A in the design of this engineered Project. The SPL’s should not be interpreted as being a pre-approved list of products necessarily meeting the requirements for a given construction Project. Items contained in the SPL cannot be substituted for items shown on the Drawings, or called for in the specifications, or specified in the Bidding Requirements, Contract Forms and Conditions of Contract, unless approved by the E/A in conjunction with the Water and Wastewater Utility Standard Products Committee. The Standard Product List current at the time of plan approval will govern.

B. Design:
1. Operation: Release accumulated air in sewage pipelines operating under pressure. After entrained air escapes through the orifice, the orifice is plugged by a needle mounted on a compound lever mechanism.

C. For wastewater services provide valves with the following:
1. Extended valve body.
2. 2-inch cleanout.

3. Minimum 2-inch inlet.
4. 1/2-inch outlet with stainless steel ball valve with hose connection. Provide 10 feet of hose with quick disconnect couplings.
5. 1-inch drain with stainless steel ball valve.
6. Orifice size: 1/4 inch diameter.
7. Internal components removable through top cover without removing valve from pipeline.
8. Provide ball valve as specified herein.

D. Valves 3-inch and Smaller: NPT inlet and outlet connections equivalent to the valve size.
1. Provide stainless steel ball valve for isolation as specified herein.

E. Valves 4-inch and Larger: Flanged inlet and outlet connections equivalent to the valve size.
1. Provide plug valve for isolation as specified herein.
2. Flanges: ANSI B16.1 Class 125.

F. Materials:
1. Body: ASTM A126 Class B Cast Iron for Class 125 valves.
2. Float: Type 316 stainless steel.
3. Needle: Buna-N.
4. Hardware: Type 316 stainless steel.
5. Interior Valve Coating: Fusion bonded epoxy.

2.06 AIR AND VACUUM VALVES, 2-INCH TO 14-INCH, SEWAGE SERVICE

A. Manufacturers: One of the following or equal:
1. DeZurik APCO Series 401 SAVV
2. Val-Matic Valve (2″-6″ only).

B. Design:
1. Operation: Automatically exhausts air during the filling of a system and allows air to re-enter during draining or when vacuum occurs.
2. Pressure rating: 150 pounds per square inch, unless otherwise noted on PLANS.

C. Accessories:
1. Inlet shutoff valve. Utilize eccentric plug valve.
2. Blowoff valves for backflushing.
3. 10 feet of hose with quick disconnect couplings.

D. Materials:
1. Body: Standard elongated body; cast iron, ductile iron, or semi-steel body.
2. Float: Type 316 stainless steel.
3. Needle: Buna-N.

2.07 COMBINATION AIR VALVE, ½-INCH TO 14-INCH, SEWAGE SERVICE

A. Manufacturers: One of the following or equal:
1. DeZUrik APCO Series 440 SCAV
2. GA Industries Fig. 942

B. Design:
1. Operation: Automatically allows large volume of air escape or enter through large diameter of orifice when filling or draining a pipeline.

2. When pipeline is filled and pressurized, the large air/vacuum orifice shall stay closed, but the smaller diameter air release orifice shall remain operative and open to allow small pockets of air accumulation to escape.
3. Pressure rating: 150 pounds per square inch, unless otherwise noted on PLANS.

C. Accessories:
1. Blowoff valves for backflushing.
2. 10 feet of hose with quick disconnect couplings.
3. Install isolation valve between parent pipe and air release valve.

D. Materials:
1. Body: Cast iron.
2. Float: Type 316 stainless steel.
3. Needle: Buna-N.
4. Lever frame: Cast iron or Delrin.

PART 3 EXECUTION

3.01 GENERAL

A. Install as specified in Section 15110 and manufacturer's instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

C. Install isolation valve between air release valve and parent pipe.

3.02 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

D. 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

SECTION 15172

ELECTRICAL MOTOR, HIGH EFFICIENCY, HORIZONTAL INDUCTION, 300 HP & SMALLER

PART 1 GENERAL

1.01 SUMMARY

A. Furnish and install mill and chemical horizontal high efficiency, squirrel cage induction motor; Design B, normal starting current and torque; furnish as integral part of rotating equipment unit. Motor to be most premium efficient type available from motor manufacturer.

1.02 RELATED REQUIREMENTS

A. PLANS, this and other TECHNICAL SPECIFICATION Sections, and equipment manufacturer requirements define voltage, speed, special features, driven equipment requirements, and special submittal data.

B. Related work as called for on PLANS or specified 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.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	Load Ratings and Fatigue Lift for Ball Bearings

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE 112	Standard Test Procedures for Polyphase Induction Motors and Generators
IEEE 841	Standard for Petroleum and Chemical Industry – Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 500 HP

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	Motors and Generators

1.04 - 1.05 (NOT USED)

1.06 SUBMITTALS

A. Furnish the following 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 information:

a. Full nameplate information in accordance with NEMA Standard MG-1; full torque; and efficiency and power factor data at full load, ¾ load, and ½ load.
b. When power factor correction capacitor is provided in motor circuit, all nameplate information affected by addition of capacitor to be corrected and submitted in addition to information described herein.
c. Speed torque characteristics, safe stall time, and thermal damage curves.
d. Space heater voltage and wattage.
e. Bearing size and calculation.
f. Data to be included on nameplate.
g. Dimensioned outlined drawings.
h. Net weight of assembled motor and net weight of heaviest part to be handled during field assembly or disassembly.
i. When power factor correction capacitors are required, include to-scale arrangement drawings showing configurations of capacitor inside the high voltage termination box.
j. Full load amperes (FLA), no load amperes, and locked rotor amperes (LRA) at rated voltage.

2. Operation and Maintenance Manuals: Furnish in accordance with Contract Documents. Manuals to contain speed-torque, safe stall time (thermal damage) and acceleration curves also.
3. Reports: Submit certified tests for review by the ENGINEER prior to shipment.

1.07 QUALITY ASSURANCE

A. Latest edition of NEMA Standard MG-1and applicable provisions of IEEE, ANSI, NEC, OSHA, and UL.

B. Furnish identical motors and accessories from a single motor manufacturer for multiple units of the same equipment.

C. Sole Source Responsibility: Utilize a single supplier to provide the drive motor, the motor mounts and any accessories.

1.08 DELIVERY, STORAGE AND HANDLING

A. Protect from weather and insects with polyethylene wrapper; furnish and energize space heaters to preclude moisture.

1.09 - 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURER(S)

A. Teco-Westinghouse;

B. General Electric;

C. U.S. Motor-Corro Duty Energy Efficient;

D. Reliance-High Performance Type XE;

2.02 MATERIALS AND/OR EQUIPMENT

A. Performance: Unless otherwise noted in the driven equipment specification sections, the following items apply as a default standard:
   1. Brake Horsepower: As designated in driven equipment specifications. Brake horsepower of the driven equipment is not to exceed the motor nameplate horsepower rating, excluding any service factor.
   2. Power Factor (as required by applicable Specification Section and/or as shown on PLANS):
      a. Minimum full load power factor (uncorrected): 85 percent.
      b. When noted on PLANS, corrected minimum full load power factor: 95 percent.
   3. Minimum Efficiency at Rating: Motors to be of a premium energy-efficient design per NEMA MG-1, 2006, Tables 12-12 and 12-13.
   4. Maximum Locked Rotor Indicating Code Letter: G for motors sized 15 horsepower and larger.

B. Application: Unless otherwise designated in the Driven Equipment Specification, furnish the following:
   1. Enclosure: TEFC.
   2. Service Factor: 1.15.
   3. Mounting: As required by the driven equipment.
   4. 120-volt space heaters.
   5. Starting: Across the line, full voltage starting except motors larger than 50 HP to be suitable for reduced voltage starting using reduced voltage solid state starters.
   6. Duty Rating: Continuous.
   7. Frequency: 60 Hz.
   8. Lifting: Lug.

C. Construction and Materials:
   1. Frame: Cast iron, size per NEMA designations.
   2. End Shields/Brackets: Cast iron.
   3. Drain/Breather: Stainless steel “T” drains in end brackets.
   4. Fan Shroud: Cast iron.
   5. Motor Terminal Box: Oversize, cast iron, diagonally split, rotatable, threaded hubs for conduit attachment. Sized per NEMA MG 1, Section 1, Paragraph 4.19. Terminal box to be gasketed to frame and furnished with grounding lug.
   6. Cooling Fan: Aluminum or polypropylene.
   7. Wiring and Insulation: Copper with nonhygroscopic Class F insulation, Class B temperature rise not to exceed insulation temperature rating when operating at service factor rating in 40°C ambient according to NEMA MG 1-12.42. Include extra dips and bakes for high humidity.
   8. Rotor: Precision cast aluminum conductor bars, statically and dynamically balanced.
   9. Bearings: Ball bearings, B_{10} life of 75,000 hours per ABMA 9, grease lubricated with cast iron bearing caps. Labyrinth sealed with removable grease relief plugs. Extended lubrication lines with Alemite fittings in both end shields. Provide for adding new and draining old grease without major motor disassembly.
   10. Hardware: Stainless steel.
   11. Shaft: High strength carbon steel, precision turned and ground. Non-metallic V-ring shaft slinger to prevent moisture seepage along shaft into motor.
   12. Power Factor Correction Capacitors (as required by applicable Specification Section and/or when shown on PLANS): Furnish capacitors of the greatest KVAR rating recommended by motor manufacturer for switching with motor. Capacitors to be provided with appropriate drain resistors per NEC and located inside motor terminal box. Furnish oversize terminal box when capacitors are required.

13. Provide internal temperature switch with contacts rated for 120 VAC, 5 amps, when shown on the PLANS. Switch settings to be at appropriate protection temperature.
14. Nameplate: Stainless steel securely attached to motor with stainless steel screws. All data to be permanently stamped into nameplate. Data to include:
    a. Horsepower.
    b. RPM.
    c. NEMA design.
    d. Phase.
    e. Hertz.
    f. Service factor.
    g. NEMA nominal efficiency.
    h. Power factor.
    i. Frame size.
    j. Duty.
    k. Class of insulation.
    l. Ambient temperature.
    m. Locked rotor KVA code.
    n. Full load amps.
    o. Locked rotor amps.
    p. Bearing identification by ABMA number.
    q. Model and catalog number.
    r. When power factor correction is provided in motor circuit, an auxiliary stainless steel nameplate to be securely attached to respective motor with stainless steel screws. Auxiliary nameplate to read "___ FLA with ____ KVAR power factor correction capacitor installed", with applicable values inserted as required. Sentence to be permanently stamped into auxiliary nameplate.
    s. Each motor is to have a stainless steel nameplate indicating essential lubrication information such as the type of lubricant, viscosity, frequency of lubrication, etc.
15. Additional Features for Motors Sized 200HP and Larger:
    a. Motor space heaters and temperature switch wired to a separate terminal box.
    b. Provide internal temperature switch with contacts rated for 120 VAC, 5 amp. Switch settings to be at appropriate protection temperature.
16. Additional Features for Motors with Power Factor Correction:
    a. High voltage terminal cabinet to be cast or fabricated steel of NEMA 4X construction, complete with hinged front doors with locking handle. Sized large enough to permit full stress cone terminations within the enclosure and to contain power correction capacitors, if required. Provide with ground lug and cable clamps for terminations. Motor leads into and out of cabinet to be sealed watertight.
    b. Low voltage terminal cabinet, of like construction to the high voltage cabinet, complete with terminal blocks. Each terminal block is to contain ten (10) spare terminal points.
    c. Capacitors to be provided when power factor correction is required. The capacitors to be installed in the high voltage terminal cabinet box. The terminal box to be sized large enough to house the capacitors.
17. Inverter Duty Motors:
    a. Variable speed drive motors are to be designed for pulse-width modulated inverter duty. Motor nameplate to note inverter duty classification.
    b. Motors to be used for inverter duty to meet requirements of NEMA MG 1, Section IV, Parts 30 and 31.
    c. Bearings to be electrically isolated to prevent stray current damage.

d. Provide internal temperature switch with contacts rated for 120 VAC, 5 amp. Switch settings to be at appropriate protection temperature.
e. Any limitations or caveats such as circuit length, cable type, or variable frequency drive characteristics are to be clearly identified in the submittal and meet the requirements shown on the PLANS and specified elsewhere in other Specification Sections.

2.03 (NOT USED)

2.04 SOURCE QUALITY CONTROL

A. Factory Tests:
1. Perform routine (production) tests on all motors in accordance with NEMA MG 1 and IEEE 112.
2. For motors 100 HP and smaller, testing can be conducted on an identical motor.
3. Testing:
a. No load power at rated voltage.
b. Locked rotor current.
c. Efficiency at 50, 75 and 100 percent of rated horsepower in accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraphs 12.59 and 12.60.
d. Power factor.
e. Speed.
f. Current at rated horsepower.
g. kW input at rated horsepower.
4. Motors larger than 100 HP are to be given a five point vibration test.

B. Test Report Forms:
1. Routine Tests: IEEE 112, Form A-1.
2. Efficiency and power factor by Test Method B, IEEE 112, Form A-2, and NEMA MG 1, Table 12-11.

PART 3 EXECUTION

3.01 - 3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Follow manufacturer's published instructions and alignment requirements for driven unit. Measure and record amperes at maximum load and verify proper overload heater selection.

3.04 - 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15181

HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Condensate-drain piping.

1.2 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Condensate-Drain Piping: 150 deg F.

1.3 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. Product Data: For each type of the following:

1. Plastic pipe and fittings with solvent cement.
2. Pressure-seal fittings.
3. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
4. Air control devices.
5. Chemical treatment.
6. Hydronic specialties.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

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

a. Anvil International, Inc.
b. S. P. Fittings; a division of Star Pipe Products.
c. Victaulic Company of America.

2. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
3. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.

E. Wrought-Copper Unions: ASME B16.22.

2.2 PLASTIC PIPE AND FITTINGS

A. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends as indicated in Part 3 "Piping Applications" Article.

2.3 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

B. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

C. Solvent Cements for Joining Plastic Piping:

1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Charlotte Pipe and Foundry Company.
   b. IPEX Inc.
   c. KBi.

3. PVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.

B. Plastic-to-Metal Transition Unions:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Charlotte Pipe and Foundry Company.
   b. IPEX Inc.
   c. KBi.
   d. NIBCO INC.

3. MSS SP-107, PVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.5 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:

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

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. Hart Industries International, Inc.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.

2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Couplings:

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

    a. Calpico, Inc.
    b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Condensate-Drain Piping: Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints for commercial spaces.

B. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints for residential spaces. Do NOT route PVC piping through air plenum.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such 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.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

M. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

3.3 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section 15060 "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 3/8 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 3/8 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

D. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.4 PIPE 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.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
3. PVC Nonpressure Piping: Join according to ASTM D 2855.

H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

I. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.5 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.

3.6 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 15181

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SECTION 15183

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

1.3 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.

C. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L or ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.

5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 115-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig.

H. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: 5 tons.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

L. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: 5 tons.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

M. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.3 REFRIGERANTS

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

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-22: Monochlorodifluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Safety-Relief-Valve Discharge Piping:

1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at strainers if they are not an integral part of strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.

F. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

G. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Compressor.

J. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

K. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. 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 Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

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 adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.

L. Install refrigerant piping in protective conduit where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

Q. Seal penetrations through fire and smoke barriers per NFPA.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

T. Seal pipe penetrations through exterior walls. Maintain envelope integrity and insulation.

U. Identify refrigerant piping and valves according to Division 15 Section "Mechanical Identification."

V. Install piping in schedule 40 PVC conduit through corrosive areas.

3.4 PIPE JOINT CONSTRUCTION

A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 15 Section 15060 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.

4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.

D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

3.9 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 15183

SECTION 15255

STAINLESS STEEL PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Stainless steel piping and tubing.

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 referenced in the text by basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
ASME B16.5	Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.B16.11 - Forged Fittings, Socket Welded and Threaded
ASME B31.3	Process Piping
ASME B36.19	Stainless Steel Pipe
ASME Section IX	Boiler and Pressure Vessel

AMERICAN WELDING SOCIETY (AWS)

AWS D1.6	Structural Welding Code - Stainless Steel

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 182	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A 193	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A 194	Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both
ASTM A 240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A 269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A 276	Standard Specification for Stainless Steel Bars and Shapes

ASTM A 312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A 351	Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A 380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A 403	Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM A 743	Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
ASTM A 744	Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
ASTM A 774	Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures
ASTM A 778	Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products
ASTM A 789	Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
ASTM A 790	Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe
ASTM A 928	Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal
ASTM A 967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
ASTM B 622	Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube
ASTM B 912	Standard Specification for Passivation of Stainless Steels Using Electropolishing
ASTM F 593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-4.1	Cleaning Equipment for Oxygen Service.

1.04 DEFINITIONS (NOT USED)

1.05 PERFORMANCE AND DESIGN CRITERIA

A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized.
   1. Piping design indicated on the PLANS illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.

2. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field assembly: Field welding is prohibited

D. Field assembly: Assemble shop-fabricated piping in the field using the joints designed into the piping layout or by using flexible couplings.

1.06 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, “Submittals” and Section 01730, “Operation and Maintenance Data”.
   1. Layout drawings: Detailed layout drawings showing dimensions and alignment of pipes; location of valves, fittings, and appurtenances; location of field joints; location of pipe hangars and supports; connections to equipment or structures; location and details of shop welds; and thickness and dimensions of fittings and gaskets.
      a. Prepare layout drawings.
   2. Product data:
      a. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
      b. Material specifications for pipe, gaskets, fittings, and couplings.
      c. Data on joint types and components used in the system including flanged joints, grooved joint couplings and screwed joints.
   3. Manufacturing certifications.
   4. Welder and weld operator qualification certificates and welding procedures.
   5. Cleaning procedures used for liquid oxygen and ozone piping systems in accordance with CGA Standard G-4.1.
   6. Source quality control test reports.

1.07 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 STAINLESS STEEL PIPE

A. GENERAL:
   1. Pipe sizes specified in the Specifications and indicated on the PLANS are nominal.

B. Wall thickness:
   1. As specified in piping schedule on the PLANS. If not scheduled, wall thickness shall be as specified below.
      a. Piping 3 inches in nominal diameter and greater:
         1) For general service applications with pressures less than 250 pounds per square inch gauge, pipe diameter 24-inches or less, minimum wall thickness corresponding to Schedule [10S].
         2) For pressures exceeding 250 pounds per square gauge, minimum wall thickness corresponding to Schedule 40S.
      b. Piping less than 3 inches in nominal diameter:
         1) Minimum wall thickness corresponding the Schedule 40S.
      c. Piping with threaded or grooved joints:
         1) For general service applications with pressures less than 250 pounds per square inch gauge, minimum wall thickness corresponding the Schedule 40S.
         2) For pressures exceeding 250 pounds per square inch gauge, minimum wall thickness corresponding to Schedule 80S.

C. Piping material and manufacturing:

1. Comply with the requirements outlined in the following table:

Service	Stainless Steel Grade	Pipe Manufacturing Process
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel in accordance with ASTM A 240	In accordance with ASTM A 778
Piping less than 3 inches in nominal diameter	Type 304L stainless steel in accordance with ASTM A 240	In accordance with ASTM A 312

D. Fittings for piping 3 inches in nominal diameter and greater:
1. Material: In accordance with ASTM A 240 stainless steel, grade to match the pipe.
2. Manufacturing standard: In accordance with ASTM A 774.
3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
4. End configuration: As needed to comply with specified type of joint.
5. Dimensional standards:
   a. Fittings with weld ends: In accordance with ASME B16.11.
   b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.

E. Fittings for piping less than 3 inches in diameter:
1. Material: In accordance with ASTM A 240 stainless steel, grade to match the pipe.
2. Manufacturing standard: In accordance with ASTM A 403, Class WP.
3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.
4. End configuration: As needed to comply with specified type of joint.
5. Forgings in accordance with ASTM A 182, or barstock in accordance with ASTM A 276. Match forging or barstock material to the piping materials.

F. Piping joints:
1. Joint types, piping greater than 2 inches in diameter, general:
   a. Where type of joint is specifically indicated on the PLANS or Specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.
   b. Where type of joint is not specifically indicated on the PLANS or as Specified, design and shop-fabricate piping sections utilizing any of the following joint types:
      1) Welded joints.
      2) Flanged joints.
      3) Grooved joints.
   c. Joints at valves and pipe appurtenances: Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends. Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using flanged coupling adapters or flanged joints.
      1) Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system, and conforming to requirements as Specified.
2. Joints in piping 2 inches in diameter and smaller: Flanged or welded.
3. Welded joints:
   a. Pipe 12 inches and larger in diameter: Automatically weld joints using gas tungsten-arc procedures.
   b. Piping 4 inches through 12 inches in diameter: Double butt welded joints
   c. Piping less than 4 inches in diameter: Single butt-welded joints.
   d. Mark each weld with a symbol that identifies the welder.
4. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150.

5. Flanges for schedule 40S and schedule 80S pipe:
    a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150.
    b. Material: In accordance with ASTM A 182.
6. Grooved joints:
    a. Pressure less than 500 pounds per square inch:
        1) Cut grooves from Schedule 40 or higher.
    b. Heavier schedule pipe sections used for cut groove ends:
        1) Tapered inside diameter to transition from the inside diameter of the lighter schedule pipe.
    c. Butt welds connecting pipes of different schedules that leave an abrupt change in inside diameter are not allowed.
    d. Couplings:
        1) Type 316 stainless steel in accordance with ASTM A 351, A 743, and A 744.
            a) Bolts: Stainless steel in accordance with ASTM F-593, Group 2, Condition CW.
            b) Nuts: Stainless steel.
            c) Manufacturers: The following or equal:
                (1) Piedmont Pacific Corporation.

G. Gaskets:
1. Low Pressure Air Service: EPDM, 1/8-inch thick, 60 durometer, as Specified.
2. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.

H. Bolts for flanges:
1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A 193 heavy hex head.
    a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
    b. Nuts: In accordance with ASTM A 194 heavy hex pattern.

I. Fabrication of pipe sections:
1. Welding: Weld as Specified.
2. Weld seams:
    a. Full penetration welds, free of oxidation, crevices, pits and cracks and without undercuts.
    b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
    c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
    d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

J. Cleaning (pickling) and passivation:
1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
2. Clean (pickle) and passivate in accordance with ASTM A 380 or A 967.
    a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible. However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
    b. Passivation treatments with citric acid are not allowed.
3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

2.02 STAINLESS STEEL TUBING

A. Stainless steel tubing:
   1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A 269, wall thickness not less than 0.035 inch.

B. Fittings: Swage ferrule design:
   1. Components made of:
      a. Type 316 stainless steel.
   2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
   3. Flare type fittings are not acceptable.
   4. Manufacturers: One of the following or equal:
      a. Crawford Fitting Company, Swagelok.
      b. Hoke, Gyrolok.
      c. Parker, CPI.

C. Valves for use with stainless steel tubing:
   1. Ball type valves with swage ends to match tubing diameter.
   2. Constructed from:
      a. Type 316 stainless steel with TFE seats.
   3. Manufacturers: The following or equal:
      a. Crawford Fitting Company, Swagelok.

2.03 FABRICATION (NOT USED)

2.04 SOURCE QUALITY CONTROL

A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

B. Provide written certification that the pipe as supplied are in accordance with ASTM A 778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied are in accordance with ASTM A 774. Supplementary testing is not required.

D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

E. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.

F. Before shipment to site: Protect all parts and flanges with foam. Palletize all stainless steel items. Cap ends of tube, piping, and pipe spools.

PART 3 EXECUTION

3.01– 3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

B. Slope horizontal lines so that they can be drained completely.

C. Provide valve drains at low points in piping systems.

D. Install eccentric reducers where necessary to facilitate draining of piping system.

E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.04 REPAIR/RESTORATION (NOT USED)

3.05 FIELD QUALITY CONTROL

A. Test piping to pressure and by method as Specified.
   1. If pressure testing is accomplished with water:
      a. Use only potable quality water.
      b. Piping: Thoroughly drained and dried or place immediately into service.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

3.06 – 3.08 (NOT USED)

3.09 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
   1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
   2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
   3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without projection from bad weather is prohibited.
   4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

3.10 SCHEDULES (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 15738

SPLIT-SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

1.2 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90. Compliance: Applicable requirements in ASHRAE/IESNA 90.1 , Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace split-system air-conditioning units that fail in materials and workmanship within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Carrier Air Conditioning; Div. of Carrier Corp.
2. Daikin
3. First Co.
4. Friedrich Air Conditioning Company.
5. Goodman
6. Lennox Industries Inc.
7. Mitsubishi Electric Sales Canada, Inc.
8. Mitsubishi Electronics America, Inc.; HVAC Division.
9. Mitsubishi Heavy Industries America, Inc.; Air-Conditioning & Refrigeration Division, Inc.
10. Trane Co. (The); Unitary Products Group.
11. York International Corp.

2.2 INDOOR EVAPORTAOR UNIT (5 TONS OR LESS)

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
5. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
6. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 15058 "Common Motor Requirements for HVAC Equipment."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.

7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
8. Filters: Disposable.
9. Condensate Drain Pans:

a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
2) Depth: A minimum of 2 inches deep.

b. Single-wall, galvanized-steel sheet.
c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

1) Minimum Connection Size: NPS 1.

d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Floor-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
   a. Insulation: Faced, glass-fiber duct liner.
   b. Drain Pans: Galvanized steel, with connection for drain; insulated.

2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Fan: Direct drive, centrifugal.
4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
5. Fan Motors:

   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 15058 "Common Motor Requirements for HVAC Equipment."
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.

6. Air Filtration Section:

   a. General Requirements for Air Filtration Section:

      1) Comply with NFPA 90A.
      2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
      3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

b. Disposable Panel Filters:

1) Factory-fabricated, viscous-coated, flat-panel type.
2) Thickness: 1 inch.
3) Merv according to ASHRAE 52.2.
4) Media: Interlaced glass fibers sprayed with nonflammable adhesive.
5) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER UNIT (5 TONS OR LESS)

A. Casing steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Compressor: Hermetically sealed scrolltype with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor. Two-speed or ECM variable speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.

1. Refrigerant: R-410A.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Condensing coils: Uniformly bonded Epoxy polimer or equivalent corrosive resistant coating for hydrogen sulfide rich applications.

E. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.

F. Fan: Aluminum-propeller type, directly connected to motor.

G. Motor: Permanently lubricated, with integral thermal-overload protection.

H. Low Ambient Kit: Permits operation down to 40 deg F.

I. Mounting Base: Polyethylene.

J. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.4 ACCESSORIES

A. Thermostat: 7-day programmable, Low voltage with subbase to control compressor and evaporator fan.

B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

1. Minimum Insulation Thickness: 1 inch thick.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

B. Install ground-mounted, compressor-condenser components on 4-inch-thick, reinforced concrete base; 4 inches larger on each side than unit. Coordinate anchor installation with concrete base.

C. Install ground-mounted, compressor-condenser components on polyethylene mounting base.

D. Install roof-mounted, compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

E. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. Refer to Division 15 Section 15074 "Vibration Controls for HVAC."

3.2 CONNECTIONS

A. Connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

B. Connect supply and return water coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

C. Connect supply and return condenser connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

D. Install piping adjacent to unit to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports

3.4 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 15738

SECTION 15739

PACKAGED, SMALL-CAPACITY, AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, small-capacity, air-conditioning units with the following components and accessories:

1. Casings.
2. Fans.
3. Motors.
4. Coils.
5. Refrigerant circuit components.
6. Air filtration.
7. Dampers.
8. Electrical power connections.
9. Controls.
10. Accessories.
11. Roof curbs.

1.2 ACTION SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. Product Data: For each PACKAGE UNIT.

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

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

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Certificates: For PACKAGE UNITs, accessories, and components, from manufacturer.

C. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 15074 "Vibration and Controls for HVAC."

D. Field quality-control reports.

E. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of PACKAGE UNITs that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. AHRI Compliance:

1. Comply with AHRI 210/240 for testing and rating energy efficiencies for PACKAGE UNITs.
2. Comply with AHRI 270 for testing and rating sound performance for PACKAGE UNITs.
3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Package Unit."

D. ASHRAE/IES Compliance: Comply with applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.

F. UL Compliance: Comply with UL 1995.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier Corporation; a unit of United Technologies Corp.
2. Goodman
3. Friedrich Air Conditioning Company.
4. Lennox Industries, Inc.; Lennox International.
5. Trane.

2.3 CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction: Fill space between walls with minimum 1-inch foam insulation and seal moisture tight for minimum R-7 performance.

C. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

1. Corrosion Protection: 500 hours' salt spray test according to ASTM B 117.

D. Inner Casing Fabrication Requirements:

1. Inside Casing: G-90-coated galvanized steel, 0.034 inch thick.

E. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C 1071, Type I.
2. Thickness: 1 inch.
3. Liner materials shall have airstream surface coated with erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
4. Liner Adhesive: Comply with ASTM C 916, Type I.

F. Plastic Condensate Drain Pans: Fabricated using rigid heavy plastic polymer, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

G. Condensate Drain Pans: Fabricated using G-90-coated galvanized-steel sheet 0.028 inch thick, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple.

H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.4 FANS

A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

1. Direct-Driven Supply-Air Fans: Motor shall be resiliently mounted in the fan inlet.
2. Belt-Driven Supply-Air Fans: Motors shall be installed on an adjustable fan base resiliently mounted in the casing.

B. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated multispeed ECM motors.

2.5 MOTORS

A. Comply with NEMA MG 1, Design B, medium induction motor, unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

C. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

D. Duty: Continuous duty at ambient temperature of 104 deg Fand at altitude of 3300 feet above sea level.

E. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

F. Efficiency: Energy efficient, as defined in NEMA MG 1.

G. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements.

H. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

I. Multispeed Motors: Separate winding for each speed.

J. Rotor: Random-wound, squirrel cage.

K. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

L. Temperature Rise: Match insulation rating.

M. Insulation: Class F.

N. Code Letter Designation:
1. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

O. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

P. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short-time rise pulses produced by pulse-width-modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Motor Bearings: Sealed.
6. Unusual Service Conditions:

a. Ambient Temperature: 105 degrees F

7. Efficiency: Premium efficient.

2.6 COILS

A. Supply-Air Refrigerant Coil:

1. Copper-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Coated.

B. Outdoor-Air Refrigerant Coil:

1. Copper-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.

C. Electric-Resistance Heating:

1. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame. Terminate

elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

2. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box.
3. Overcurrent Protection: Manual-reset thermal cutouts, factory wired in each heater stage.
4. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:

    a. Magnetic contactors.
    b. Step Controller: Pilot lights and override toggle switch for each step.
    c. SCR Controller: Pilot lights operate on load ratio, a minimum of five steps.
    d. Time-delay relay.
    e. Airflow proving switch.

2.7 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, digital scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.

2.8 AIR FILTRATION

A. Minimum arrestance and MERV according to ASHRAE 52.2.

2.9 DAMPERS

A. Leakage Rate: Comply with ASHRAE/IES 90.1.

B. Damper Motor: Modulating with adjustable minimum position.

2.10 ELECTRICAL POWER CONNECTIONS

A. PACKAGE UNIT shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.11 CONTROLS

A. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:

a. Heat-cool-off switch.
b. Fan on-auto switch.
c. Fan-speed switch.
d. Automatic changeover.
e. Adjustable deadband.
f. Exposed set point.
g. Exposed indication.
h. Degree F indication.
i. Unoccupied-period-override push button.
j. Data entry and access port to input temperature set points, occupied and unoccupied periods, and output room temperature, supply-air temperature, operating mode, and status.

B. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:

a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
c. Retain "Defrost Control for Condenser Coil" Subparagraph below for air-to-air heat-pump feature.
d. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.

3. Scheduled Operation: Occupied and unoccupied periods on seven 365-day clock with a minimum of four programmable periods per day.
4. Unoccupied Period:

a. Heating Setback: 8 deg F.
b. Cooling Setback: System off.
c. Override Operation: Two hours.

5. Supply Fan Operation:

a. Occupied Periods: Run fan continuously.
b. Unoccupied Periods: Cycle fan to maintain setback temperature.

6. Refrigerant Circuit Operation:

a. Occupied Periods: Cycle or stage compressors to match compressor output to cooling load to maintain room temperature. Cycle condenser fans to maintain maximum hot-gas pressure.
b. Unoccupied Periods: Compressors off.

7. Electric-Heating-Coil Operation:

a. Occupied Periods: Stage coil to maintain room temperature.
b. Unoccupied Periods: Energize coil to maintain setback temperature.

8. Fixed Minimum Outdoor-Air Damper Operation:

a. Occupied Periods: Open to 25 percent.
b. Unoccupied Periods: Close the outdoor-air damper.

C. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide LonWorks or BACnet (as coordinated with the owner prior to purchase) compatible interface for central HVAC control workstation for the following:

a. Adjusting set points.
b. Monitoring supply fan start, stop, and operation.
c. Inquiring data to include supply- and room-air temperature.
d. Monitoring occupied and unoccupied operations.
e. Monitoring constant and variable motor loads.
f. Monitoring cooling load.
g. Monitoring air-distribution static pressure and ventilation air volume.

2.12 ACCESSORIES

A. Electric heater with integral thermostat maintains minimum 50 deg F temperature in gas burner compartment.

B. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required.

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

D. Factory- or field-installed, demand-controlled ventilation.

E. Safeties:

1. Smoke detector.
2. Condensate overflow switch.
3. Phase-loss reversal protection.
4. High and low pressure control.

5. Electric coil airflow-proving switch.

F. Coil guards of painted, galvanized-steel wire.

G. Hail guards of galvanized steel, painted to match casing.

H. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

I. Door switches to disable heating or reset set point when open.

J. Outdoor-air intake weather hood with moisture eliminator.

K. Oil separator.

L. Service Lights and Switch: Factory installed in each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install ground-mounted package unit on 4-inch-thick, reinforced concrete base; 6 inches larger on each side than unit. Coordinate anchor installation with concrete base

3.2 CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to PACKAGE UNITs with flexible duct connectors specified in Section 15820 " Duct Accessories."
4. Install return-air duct continuously through roof structure.

B. Install condensate drain per drawings.

C. Where installing piping adjacent to PACKAGE UNITs, allow space for service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. After installing PACKAGE UNITs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. PACKAGE UNIT will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing PACKAGE UNIT and air-distribution systems, clean filter housings and install new filters.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain PACKAGE UNITs.

END OF SECTION 15739

SECTION 15815

METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings
3. Single-wall round ducts and fittings.
4. Double-wall round ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.

B. Related Sections:
1. Division 15 Section 15820 "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
2. Division 15 Section 15950 "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing requirements for metal ducts.

1.2 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.

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.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

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. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

D. 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. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

E. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to

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

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL 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."

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide MKT Metal Manufacturing; MKT Double-Wall Rectangular Ducts and Fittings, or a comparable product by one of the following:

1. McGill AirFlow LLC.
2. Sheet Metal Connectors, Inc.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse 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."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," 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."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   2. Coat insulation with antimicrobial coating.
   3. Cover insulation with polyester film complying with UL 181, Class 1.

G. Inner Duct: Minimum 0.028-inch solid sheet steel.

H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse 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."

2.3 Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," 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."

2.4 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

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

      a. Ductmate Industries, Inc.

b. Elgen Manufacturing.
c. MKT Metal Manufacturing.
d. Set Duct Manufacturing.
e. Stamped Fittings Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," 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."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," 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."

1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," 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."

2.5 DOUBLE-WALL ROUND DUCTS AND FITTINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide MKT Metal Manufacturing; MKT Double-Wall Round Ducts and Fittings, or a comparable product by one of the following:

1. McGill AirFlow LLC.
2. SEMCO LLC.
3. Sheet Metal Connectors, Inc.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse 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."

a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," 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."

    a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
    b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," 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. Inner Duct: Minimum 0.028-inch solid sheet steel.

D. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
2. Coat insulation with antimicrobial coating.
3. Cover insulation with polyester film complying with UL 181, Class 1.

2.6 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. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. 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.

2.7 DUCT LINER

A. Internal duct liner shall NOT be used for insulation and shall only be used as indicated on the drawings for sound attenuation.

B. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

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

a. CertainTeed Corporation; Insulation Group.
b. Johns Manville.
c. Knauf Insulation.
d. Owens Corning.

2. Maximum Thermal Conductivity:

a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
4. Solvent-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

a. 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. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick aluminum; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

    a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 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: 4 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.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.9 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. 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."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. 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.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 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. Comply with requirements in Division 15 Section "Duct Accessories" for fire and smoke 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."

3.2 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.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 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."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. 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.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 15 Section 15820 "Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 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 "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.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.8 START UP

A. Air Balance: Comply with requirements in Division 15 Section 15950 "Testing, Adjusting, and Balancing."

3.9 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 1-inch wg.
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 12.

d. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless-Steel Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum.

G. Liner:

1. Transfer Ducts: Fibrous glass, Type I, 1 inch thick.

H. 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.

I. 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.

3.10 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 15815

SECTION 15820

DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Flexible ducts.
11. Duct accessory hardware.

1.2 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. Product Data: For each type of product indicated.

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control damper installations.
d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
e. Wiring Diagrams: For power, signal, and control wiring.

D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

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 AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.1 MATERIALS

A. 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. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. 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.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Duro Dyne Inc.
5. Greenheck Fan Corporation.
6. Lloyd Industries, Inc.
7. Nailor Industries Inc.

8. NCA Manufacturing, Inc.
9. Pottorff; a division of PCI Industries, Inc.
10. Ruskin Company.
11. SEMCO Incorporated.
12. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.052-inch-thick, galvanized sheet steel, with welded corners and mounting flange.

F. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked.

I. Blade Axles:

1. Material: Nonferrous metal.
2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.

    a. Sleeve Thickness: 20-gage minimum.
    b. Sleeve Length: 6 inches minimum.

6. Screen Mounting: Rear mounted.
7. Screen Material: Galvanized steel.
8. Screen Type: Bird.
9. 90-degree stops.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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

    a. Air Balance Inc.; a division of Mestek, Inc.
    b. American Warming and Ventilating; a division of Mestek, Inc.
    c. Flexmaster U.S.A., Inc.
    d. McGill AirFlow LLC.
    e. METALAIRE, Inc.
    f. Nailor Industries Inc.
    g. Pottorff; a division of PCI Industries, Inc.
    h. Ruskin Company.
    i. Trox USA Inc.
    j. Vent Products Company, Inc.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Nonferrous metal.
7. Bearings:

    a. Oil-impregnated bronze.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

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

    a. Air Balance Inc.; a division of Mestek, Inc.

b. American Warming and Ventilating; a division of Mestek, Inc.
c. Flexmaster U.S.A., Inc.
d. McGill AirFlow LLC.
e. METALAIRE, Inc.
f. Nailor Industries Inc.
g. Pottorff; a division of PCI Industries, Inc.
h. Ruskin Company.
i. Trox USA Inc.
j. Vent Products Company, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
e. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

6. Blade Axles: Galvanized steel.
7. Bearings:

a. Oil-impregnated bronze.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

C. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Duro Dyne Inc.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. Lloyd Industries, Inc.
8. M&I Air Systems Engineering; Division of M&I Heat Transfer Products Ltd.
9. McGill AirFlow LLC.
10. METALAIRE, Inc.
11. Metal Form Manufacturing, Inc.
12. Nailor Industries Inc.
13. NCA Manufacturing, Inc.
14. Ruskin Company.
15. Vent Products Company, Inc.
16. Young Regulator Company.

B. Frames:

1. Hat shaped.
2. Galvanized-steel channels, 0.064 inch thick.
3. Mitered and welded corners.

C. Blades:

1. Multiple blade with maximum blade width of 8 inches.
2. Parallel- and opposed-blade design (as indicated on drawings).
3. Galvanized steel.
4. 0.064 inch thick.
5. Blade Edging: Closed-cell neoprene edging.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

D. Blade Axles: 1/2-inch-diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

E. Bearings:

1. Oil-impregnated bronze.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.5 FIRE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. McGill AirFlow LLC.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. NCA Manufacturing, Inc.
9. PHL, Inc.
10. Pottorff; a division of PCI Industries, Inc.
11. Prefco; Perfect Air Control, Inc.
12. Ruskin Company.
13. Vent Products Company, Inc.
14. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

K. Heat-Responsive Device: Electric resettable link and switch package, factory installed, 165 deg F rated.

2.6 SMOKE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. PHL, Inc.
6. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Curtain type with blades inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

F. Leakage: Class I .

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

I. Damper Motors: two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:

1. Auxiliary switches for signaling fan control orposition indication].

2.7 FLANGE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.8 TURNING VANES

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. METALAIRE, Inc.
4. SEMCO Incorporated.
5. Ward Industries, Inc.; a division 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. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

E. Vane Construction: Doublewall.

F. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.9 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
4. Flexmaster U.S.A., Inc.
5. Greenheck Fan Corporation.
6. McGill AirFlow LLC.
7. Nailor Industries Inc.
8. Pottorff; a division of PCI Industries, Inc.
9. Ventfabrics, Inc.
10. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

1. Door:

    a. Double wall, rectangular.
    b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    c. Vision panel.
    d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
    e. 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.

2.10 DUCT ACCESS PANEL ASSEMBLIES

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

1. Ductmate Industries, Inc.
2. Flame Gard, Inc.
3. 3M.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.11 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.
4. Ward Industries, Inc.; a division 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 2 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.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Minimum Tensile Strength: 500 lbf/inch in the warp and 440 lbf/inch in the filling.

3. Service Temperature: Minus 50 to plus 250 deg F.

G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.12 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

C. Noninsulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 175 deg F.

D. Noninsulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.

E. Noninsulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.

F. Noninsulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil.

1. Pressure Rating: 8-inch wg positive or negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 100 to plus 435 deg F.

G. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

H. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

I. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
2. Non-Clamp Connectors: Adhesive plus sheet metal screws.

2.13 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 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 backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. 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 equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors; and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream from turning vanes.
9. Control devices requiring inspection.
10. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. 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.

K. Label access doors according to Division 15 Section 15077 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

O. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

P. Install duct test holes where required for testing and balancing purposes.

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

3.3 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 15820

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SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round ceiling diffusers.
2. Rectangular and square ceiling diffusers.
3. Louver face diffusers.
4. Adjustable bar registers and grilles.
5. Fixed face registers and grilles.

B. Related Sections:
1. Division 15 Section 15820 "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.2 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. 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.

C. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 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. A-J Manufacturing Co., Inc.
b. Anemostat Products; a Mestek company.
c. Carnes.

d. Hart & Cooley Inc.
e. Krueger.
f. METALAIRE, Inc.
g. Nailor Industries Inc.
h. Price Industries.
i. Titus.
j. Tuttle & Bailey.

2. Accessories:

a. Equalizing grid.
b. Plaster ring.
c. Safety chain.
d. Wire guard.
e. Sectorizing baffles.
f. Operating rod extension.

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. A-J Manufacturing Co., Inc.
b. Anemostat Products; a Mestek company.
c. Carnes.
d. METALAIRE, Inc.
e. Nailor Industries Inc.
f. Price Industries.
g. Titus.
h. Tuttle & Bailey.

2. Accessories:

a. Square to round neck adaptor.
b. Adjustable pattern vanes.
c. Throw reducing vanes.
d. Equalizing grid.
e. Plaster ring.
f. Safety chain.
g. Wire guard.
h. Sectorizing baffles.
i. Operating rod extension.

2.2 REGISTERS AND GRILLES

A. Adjustable Bar 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. A-J Manufacturing Co., Inc.
b. Anemostat Products; a Mestek company.
c. Carnes.
d. Dayus Register & Grille Inc.

e. Hart & Cooley Inc.
f. Krueger.
g. METALAIRE, Inc.
h. Nailor Industries Inc.
i. Price Industries.
j. Titus.
k. Tuttle & Bailey.

2. Mounting Frame: Filter.
3. Mounting: Countersunk screw.
4. Damper Type: Adjustable opposed blade.
5. Accessories:

a. Rear-blade gang operator.
b. Filter.

B. Adjustable Bar 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. A-J Manufacturing Co., Inc.
b. Anemostat Products; a Mestek company.
c. Carnes.
d. Dayus Register & Grille Inc.
e. Hart & Cooley Inc.
f. Krueger.
g. METALAIRE, Inc.
h. Nailor Industries Inc.
i. Price Industries.
j. Titus.
k. Tuttle & Bailey.

2. Material: Steel.
3. Finish: Baked enamel, color selected by Architect.
4. Rear-Blade Arrangement: Horizontal spaced apart.
5. Mounting: Countersunk screw.

6. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
7. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. A-J Manufacturing Co., Inc.
b. Anemostat Products; a Mestek company.
c. Carnes.
d. Dayus Register & Grille Inc.
e. Hart & Cooley Inc.
f. Krueger.
g. Nailor Industries Inc.
h. Price Industries.
i. Titus.

j. Tuttle & Bailey.

8. Mounting: Countersunk screw.
9. Damper Type: Adjustable opposed blade.

C. 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. A-J Manufacturing Co., Inc.
b. Anemostat Products; a Mestek company.
c. Carnes.
d. Dayus Register & Grille Inc.
e. Hart & Cooley Inc.
f. Krueger.
g. Nailor Industries Inc.
h. Price Industries.
i. Titus.
j. Tuttle & Bailey.

2. Material: Steel.
3. Finish: Baked enamel, color selected by Architect.

2.3 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

3.1 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.

3.2 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.3 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 15855

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SECTION 15950

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

a. Constant-volume air systems.
b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

a. Constant-flow hydronic systems.
b. Variable-flow hydronic systems.

1.2 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.

1.3 SUBMITTALS

A. Submit following shop drawings in accordance with Section 01300 and Specification Section 01730 “Operation and Maintenance Data”

B. 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.

C. Certified TAB reports.

1.4 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 approved by Architect Construction Manager and the Commissioning Authority.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 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 test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and 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 and underfloor air 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 15815 "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 and pump 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 terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. 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.

3.2 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. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.

7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

1. Comply with requirements in ASHRAE 62.1, 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 15083 "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.

3.4 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. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. 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.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Division 15 Section 15815 "Metal Ducts."

3.5 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.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. 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.
6. Obtain approval from Construction Manager and Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 15 Sections 15738 and 15739 for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
7. 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.

3.6 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.

3.7 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.

3.8 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.9 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.

3.11 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.

B. Status Reports: Prepare monthly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

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 and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

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.

3.14 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 15950

SECTION 16120

480 VOLT MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Scope of Work
   1. The Contractor shall furnish and install the motor control centers as specified herein and as shown on the PLANS.

1.02 RELATED WORK NOT INCLUDED

A. The PLANS designate the type, number, size and rating of devices included in the Motor Control Centers (MCCs)

B. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 QUALIFICATIONS

A. The manufacturer of the MCCs shall also manufacture the majority of components and subsystems therein (i.e., circuit breakers, starters, controls relays, etc.)

B. The MCCs shall be designed, constructed, and tested in accordance with the latest applicable requirements of NEMA, ANSI, UL, and NEC standards.

C. MCCs shall be as manufactured by Square D Company, Asea Brown Boveri, Allen-Bradley, or Eaton Cutler-Hammer Corporation, or approved equal.

1.04 SUBMITTALS

A. Submit shop drawings in accordance with the requirements of Section 01300 of the Contract Specifications. Include:
   1. Dimensioned/scaled top and bottom views, front elevations, and internal component/device layouts
   2. One-line diagrams and wiring diagrams,
   3. Catalog cut sheets. Include protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves, where applicable.
   4. Key interlock scheme drawing and sequence of operations, where applicable.
   5. As a minimum, the Contractor shall provide the recommended VFD type (Constant Torque, Variable Torque) to the MCC manufacturer in accordance with the pump/motor manufacturer's recommendations and requirements necessary for the pump/motor manufacturer to satisfy the driven equipment performance requirements. Submittals to reflect the recommended VFD type provided by the Contractor.

1.05 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. Sealed and signed arc flash hazard analysis, harmonic study, motor starting, short circuit, and coordination study report. Report to include all final setpoints used.

B. Additional information as required by subsection 1.08, this section of the Specifications.

1.06 STORAGE AND HANDLING

A. Protection
   1. The Contractor, and hence the MCC supplier, shall be responsible for safety of the MCC during storage, transporting and handling.
   2. The MCC shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment.
   3. At all times the MCC shall be housed inside a moisture free, non-porous, extra heavy duty plastic weatherproof housing.
   4. Interior and exterior of MCC shall be kept clean at all times.
   5. Energize the space heaters within the MCC 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 one day 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.

1.07 TOOLS AND SPARE PARTS

A. Furnish the following spare parts with the equipment for each MCC in conformance with the specifications:
   1. One (1) – Set of fuses (minimum 3) for each type and size used.
   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. Two (2) - Contactor coils for every NEMA size and type starter installed, a minimum of one coil per size.
   4. Two (2) - Spare control relays for each type used. Control relay shall be furnished complete with relay coils, Four (4) Normally Open (N.O.) contacts, Four (4) Normally Closed (N.C.) contacts, and shall be furnished with Relay Manufacturer's Transient Voltage Suppression Module.
   5. One (1) - Spare timing relay.
   6. Two (2) – Sets of overload heaters for each size and type used.
   7. One (1) quart of manufacturer's standard touch-up paint.
   8. One (1) Power Monitoring Unit, where Power Monitoring Units are required by the PLANS.
   9. One (1) - Spare elapsed time meter for each motor control center in which an elapsed time meter is used.

B. Furnish the following tools with the equipment for each MCC in conformance with the specifications:
   1. Provide breaker test set for Solid-State-Trip units for each type used.

1.08 SPECIAL MANUFACTURER SERVICES

A. Prepare an arc-flash hazard analysis study, harmonic study, and a coordination study, complete with short circuit calculations and coordination curves reflecting calculated fault values and recommended and/or proposed fuse type/ratings, motor protective relay settings, equipment/device settings (as applicable) from the 12470V level (with close coordination with the Owner's upstream 12470V protective devices) through the 208/120V subsystem level equipment and devices of the Primary Treatment Complex No. 2 Building. Thevenin equivalent system characteristics for the existing 12470V system serving the existing 12470V:480V transformers "PTC2-XFMR-01A" and "PTC2-XFMR-01B" will be provided by the Owner after Bid Award to facilitate the Contractor's system study effort. Coordination with the Owner is required. Additional details concerning the implementation of the short circuit, coordination, arc flash, and harmonic studies such as main-tie-tie-main circuit breaker states to be assumed, etc., will be provided after Bid Award. Information associated with existing loads to be included in the system studies such as motor speed-torque curves, blower speed-torque curves, blower inertia, etc., shall be provided by the Owner after Bid Award. Exception: existing protective device (circuit breaker, fuse, etc.) performance curves, cable damage curves, and other data commonly available via system analysis software packages will not be provided by the Owner.

B. Prepare motor starting studies, complete with load calculations and voltage dip curves reflecting calculated load, voltage, motor and load speed-torque characteristics and values, tabulated voltage dip duration and magnitude at the

15kV level, and recommended and/or proposed protective relay settings, equipment/device settings (as applicable), etc. for all proposed motor starters/distribution equipment on the project. In the studies, include the previously mentioned Thevenin equivalent system characteristics for the existing 12470V system serving the existing 12470V:480V transformers “PTC2-XFMR-01A” and “PTC2-XFMR-01B” provided by the Owner. All studies shall be performed assuming each pump starts against a closed discharge valve. Verify and coordinate the validity of these assumptions and the sequence of valve operation with the Owner after Bid Award and follow the recommendations of the Owner regarding the process system operation. Additionally, perform all motor starting studies assuming one main 12470V utility service is energized, the tie circuit breakers are closed, and the second 12470V utility service is de-energized. Perform the motor starting studies for the sequential progressive starting of the proposed motors. Repeat studies for each Preliminary Treatment Complex No. 2 Building 480V electrical service.

C. The study should also include adjustments/recommendations in the proposed/new protective relaying devices to better coordinate with the existing upstream protective devices in lieu of replacing any of the existing protective devices. The study shall also include any adjustments, recommendations, and requirements of the Owner and be fully coordinated with the Owner and the Owner’s requirements. Coordinate with the Owner as required and submit documentation as required to meet the Owner’s requirements at no additional cost to the Owner. The manufacturer’s services should also include setting/re-adjusting and testing/calibration of the proposed protective devices and protective relaying, etc. (Referenced below).

D. Perform the arc flash hazard analysis in conjunction with the short circuit and coordination analysis previously described herein and also in compliance with IEEE 1584 and NFPA 70E standards. The flash protection boundary and incident energy shall be calculated at all points in the distribution system (transformers, motor control centers, panelboards, etc.) where work could be performed on energized parts. The following additional requirements apply for the arc flash hazard analysis:
   1. Perform arc flash hazard studies assuming one main 480V utility service is energized, the tie circuit breakers are closed, and the second 480V main utility service is de-energized.
   2. Repeat studies for each electrical service.
   3. Calculations to address worst case (maximum) hazard analysis. Describe scenario employed in submittals.
   4. Perform analysis for one (1) additional configuration of main-tie-main switch/breaker positions that will be explained by the Owner after bid-award.

E. The arc flash hazard analysis effort shall also include:
   1. Reporting incident energy values based upon recommended protective device settings for all equipment.
   2. Reporting recommendations to reduce AFIE levels and enhance worker safety.
   3. Furnish and install label(s) for all equipment included in the study indicating the following, at minimum:
      a. System voltage
      b. Shock and Flash protection boundaries

c. Personal protective equipment requirements for each electrical task based upon hazard category (including flame resistant clothing requirements).
d. Arc flash incident energy value (cal/cm2)
e. Limited, restricted, and prohibited approach boundaries
f. Study report number and issue date
g. Additional information required by the applicable NFPA and IEEE standards.
h. Labels shall be manufacturer's standard labels with quantity and mounting location per manufacturer's standard.

F. Perform a harmonic study in accordance with IEEE 519 from the 12470V level (with close coordination with the Owner's upstream 12470V protective devices) through the 208/120V subsystem level equipment and devices of the Primary Treatment Complex No. 2 Building. In the studies, include the previously mentioned Thevenin equivalent system characteristics for the existing 12470V system serving the existing 12470V:480V transformers "PTC2-XFMR-01A" and "PTC2-XFMR-01B" provided by the Owner. Include all necessary equipment (motor control center, switchboard, panelboard, transformer, feeders, loads, etc.) as required to demonstrate compliance with the harmonic performance requirements in the specific locations as shown on the PLANS. Refer to the PLANS. Additionally, comply with the following:
1. The harmonic performance shall meet the following minimum performance requirements at the location identified on the PLANS.
2. Compliance with latest version IEEE 519, with the location identified the PLANS serving as the IEEE 519 "point of common coupling".
3. Should a supplemental harmonic filter be required over and above the VFD product requirements shown the one-line diagrams in order to meet the above harmonic performance requirements, the OWNER will select the characteristics of the harmonic filter that are most suitable for the system in providing compliance to the harmonic performance requirements. The selection will be based in part on the harmonic study performed in compliance with Section 16120 of the Specifications "480 Volt Motor Control Centers", paragraph 1.08 "Special Manufacturer's Services". The Manufacturer shall furnish the harmonic filter of the appropriate characteristics that shall be the most suitable for the proposed operation of the system, complete with conduit/wire, at No Additional Cost to the OWNER. Furnishing a supplemental harmonic filter shall in no way relieve the Contractor from furnishing and installing the minimum VFD product requirements shown on the Contract Documents.

G. THE ARC-FLASH STUDIES, THE SHORT CIRCUIT CALCULATIONS AND ANALYSIS, THE COORDINATION STUDY, AND THE MOTOR STARTING STUDIES, AND HARMONIC STUDY SHALL BE PERFORMED:
1. UTILIZING SKM SOFTWARE, LATEST RELEASE – MICROSOFT WINDOWS VERSION. In addition to the hard copy submittal, an electronic copy of the FINAL VERSION of the short circuit analysis/calculations and the protective device setting curves (time-current curves) and summary setting tables, etc. shall be submitted on a Universal Serial Bus (USB) external flash drive.

2. By a State of Texas Licensed Professional Electrical Engineer. The final version of the studies shall be signed and sealed by a Professional Engineer who is licensed in the State of Texas as an electrical engineer.

H. Furnish the services of a qualified, experienced, factory trained technical (non-sales type) representative to assist in the installation of the equipment. Include checking alignment of parts, wiring connections, operation of all parts (relays, starters, monitoring relays, 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, adjusted, properly tested, and set in accordance with the manufacturer's recommendations and is in satisfactory operating condition. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications.

I. Manufacturer's technical representative is to set, adjust and test all protective relays, etc. in the presence of a representative of the Owner. The settings will be based on coordination and short circuit studies performed in compliance with Section 16120 of the Specifications "480 Volt Motor Control Centers", paragraph 1.08 "Special Manufacturer's Services". Provide the Owner with 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 of the Specifications. 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 at No Additional Cost to the Owner.

J. Any problems encountered with the operation of equipment, parts, components, etc. installed within the MCC line-up shall be repaired/remedied by the manufacturer's technical representative.

PART 2 PRODUCTS

2.01 GENERAL

A. For additional construction notes and special requirements, refer to the PLANS. Also refer and adhere to the requirements of the PLANS.

B. Motor Control Center shall not exceed the dimensions shown on the PLANS. Compartment/component arrangement shall be as shown on the elevation drawings. Provide for incoming feeder entering from below or above, and for outgoing circuits exiting from above and below, as shown on the PLANS.

2.02 CONSTRUCTION

A. Structure
1. Enclosures shall be NEMA Type 1, Gasketed. Enclosure shall be the totally enclosed, dead front, free standing type suitable for back-to-wall mounting.
2. MCC shall consist of required number of vertical sections bolted together to form a rigid self supporting assembly. Each vertical section shall be nominally 90 inches high. Each vertical section shall be subdivided into compartments (units). Refer to the PLANS for additional dimensional requirements.

3. The MCC shall contain a top horizontal wireway and a bottom horizontal wireway running the full width of the MCC. The bottom horizontal wireway shall be covered by hinged doors. Each vertical section shall include a top plate and a bottom plate; plates shall be removable.
4. Each vertical section containing a plug-in unit shall also contain a vertical wireway that interconnects the top and bottom horizontal wireways. The vertical wireway shall be covered by a hinged door.
5. Each unit within each vertical section shall have a hinged door. Each unit shall have a padlockable disconnect operating handle. Include provisions for up to three padlocks. Handle shall be mechanically interlocked with the door to prevent personnel from opening the door when the unit disconnect is in the ON position. Provide handle-door interlock defeating (bypass) feature. Provide non-defeatable interlock to prevent the installation of a plug-in unit unless the unit disconnect is in the OFF position.
6. Unused unit spaces in each vertical section shall be covered by hinged blank doors and equipped to accept future units.
7. All combination starter and feeder units of plug-in construction shall utilize mechanical guides to insure positive alignment of the unit stabs to the section vertical bus. For each unit, shutters shall be provided to cover bus access openings when unit is removed. Unused structure openings shall have plugs or covers to prevent entry of foreign objects into the bus area.
8. Structure finish shall be primed and painted using the manufacturer's standard finishing process. Finish shall be applied at the manufacturing plant. Color shall be manufacturer's standard.
9. Provide each vertical section with an accessible space heater wired to terminal blocks in the respective section. Size the space heater per manufacturer's standard.
10. Structure shall include field removable lifting means.
11. Where an incoming line section is required by the PLANS, the Incoming Line Section shall include lugs for the connection of the field wiring shown on the PLANS.

B. Buses
1. All buses shall be tin plated copper.
2. The main horizontal bus shall extend the entire length of the motor control center. Buses shall be fully rated and the rating shall be based on 65 degrees C maximum temperature rise in a 40 degree C ambient. The main bus shall be rated as shown on the drawings and/or data sheets. Provisions shall be provided to facilitate future extension of the buses.
3. The vertical bus in each section shall be rated for 300 ampere, at minimum.
4. The minimum RMS symmetrical short circuit current rating of the buses shall be as indicated on the one-line diagram drawings.
5. The power buses shall be isolated by barriers from starters, wire troughs, and other areas.
6. A continuous ground bus shall be furnished for the entire length of the MCC. The ground bus shall be rated for 50 percent of the main horizontal power (phase) bus rating, at minimum. Stack multiple ground bus bars as required to provide the required ground bus rating. Provide ground bolted connectors for the size and quantity of wire at each end of the bus as shown on the PLANS.

C. Wiring

1. Unless otherwise noted, the MCC shall be wired Class II, type B construction with terminal blocks for each cubicle.
2. All control wiring shall be tin-plated stranded copper not smaller than #14.
3. All wiring shall be neatly bounded with tie-wraps and supported to wire ways supports.
4. Wiring shall be terminated to split-type terminal blocks.

D. Identification
1. All component and control identification labels shall include the device name and number exactly as it appears on the PLANS. Refer to the PLANS.
2. All control wires shall be tagged and coded with an identification number. Tagging type and wire coding shall be per manufacturer's standard.
3. All terminal blocks shall be identified.
4. Properly label the devices mounted inside each section using manufacturer's standard laminated labels installed in accordance with the manufacturer's standard method.
5. 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: Engraved through the face layer to the melamine middle layer. Nameplates located on the face of each section/compartment of each MCC shall be legible at a distance of six feet from the nameplate.
   d. Accessories: Provide holes for mechanical fastening
   e. Attachment Means: Secured with two Stainless Steel screws/bolts per manufacturer's standard; use of adhesives shall not be accepted.
6. Furnish and install nameplates for:
   a. Each equipment/device/etc. installed/mounted on the face of the MCC.
   b. Each exterior section/compartment of each MCC.
   c. Overall entire lineup of MCC, i.e. a master nameplate. In addition to manufacturer's standard information for master nameplates, Master nameplate shall include, at minimum, the tag of the MCC as shown on the PLANS and all information required by the NEC.

2.03 MAIN AND TIE CIRCUIT BREAKERS

A. Rating: Circuit breaker shall be three pole, 600V with a maximum continuous current carrying capacity shown on the PLANS and a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than 42,000 amperes at 480V A.C. Breaker shall be U.L. listed and comply with NEMA Standard No. AB1-1975 and Federal Specification W-C-3758/GEN 21a. Circuit breaker shall be fully rated and not require rating for ambient temperatures 40 degrees Celsius or less.

B. The circuit breakers shall be fixed mounted power operated. The breakers shall be operated by a motor charged stored energy spring mechanism, charged normally by a universal electrical motor, remotely operated from the Distributed Control System, and in an emergency by a manual handle. The primary disconnecting contacts shall be tin-plated copper. The breaker shall include a provision for padlocking

open to prevent manual or electric closing. The padlocking shall also secure the breaker in the connected test, or disconnect position by preventing levering. The circuit breaker shall be manufactured by “Square D” model “Masterpact NW Series” or approved equal.

C. The circuit breakers shall be furnished with the following accessories and options:
   1. Shunt Trip Device
   2. Shunt Close Device
   3. Ready-to-Close Contact
   4. Electrical Closing Pushbutton
   5. Auxiliary Position Switches
   6. Overcurrent Trip Switch
   7. Micrologic Trip Unit Accessories: Circuit breakers shall have an electronic trip (solid state) unit. Trip unit shall be solid state with adjustable long time, short time, instantaneous with ground fault and pick up settings, “Square D” – model Micrologic Trip Unit with Harmonic Metering with specified accessories, with the shunt Trip Unit Attachment, and Internal Ground Fault Protection, or approved equal. Construction shall allow connection of supply conductors at either end.
      a. External Neutral Current Transformer
      b. Metering current Transformers
      c. Voltage Measurement Inputs
      d. Sensor Plugs
      e. Adjustable Rating Plugs
      f. External Power Supply Module
      g. External Battery Backup Module
   8. Mechanical operations counter to record the number of circuit breaker operations.

D. The 120VAC source for each MAIN and TIE circuit breaker shall be supplied from a dedicated control power transformer internal to the MCC assembly and connected to the line side of the circuit breaker terminals. The control power transformer(s) shall be provided with fused primary windings and fused secondary windings as specified hereinafter. The Manufacturer shall size the control power transformer, fuses and related interconnect wiring.

E. Provide each circuit breaker with the following 120VAC operators: REMOTE OFF-REMOTE ON selector switch. Selector switch shall be as specified in Section 17200 “Instrumentation and Control Cabinets and Associated Equipment”. All breaker control devices shall be wired in accordance to the manufacturer’s standard control wiring diagram for power operated circuit breakers. Wire an additional REMOTE OFF-REMOTE ON selector switch contact to control wiring terminal blocks located within the breaker unit compartment indicating that the selector switch is in the “REMOTE ON” position. The selector switch will be monitored by the Distributed Control System as shown on the PLANS.

F. Each circuit breaker shall be furnished with Normally Open (N.O.) and Normally Closed (N.C.) auxiliary breaker status contacts that will change state when the breaker is opened and/or closed. The auxiliary breaker status contacts shall be rated 5-amps at 120VAC. Pre-wire both status contacts to the control wiring

terminal blocks located within the breaker unit compartment to be monitored by the Distributed Control System as shown on the PLANS.

G. Provide each circuit breaker with the components required to comply with the Main and Tie Circuit Breaker Control Wiring Schematics shown on the PLANS.

H. Terminations: Breakers shall have removable lugs, U.L. listed for copper and aluminum conductors and U.L. listed for installation of mechanical screw type lugs.
   1. Lugs shall be able to accept the quantity of parallel conductors per phase and the size conductor shown on the PLANS. Refer to the PLANS.

2.04 BRANCH FEEDER CIRCUIT BREAKERS

A. Provide thermal magnetic molded case circuit breakers with the following minimum requirements:
   1. U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than that of the main bus.
   2. Circuit breaker shall be three pole, 600 volt with a maximum continuous current carrying capacity shown on the PLANS.
   3. 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.
   4. 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. The design shall provide common tripping of all poles. Breakers shall be suitable for reverse feeding.
   5. Provide complete with rating plug and other accessories as required for proper operation of circuit breaker.
   6. Provide mechanical padlock attachment for each circuit breaker.
   7. Furnish lugs for feeders where required to facilitate field wiring termination, sizes shall be as required by the PLANS.
   8. All circuit breakers shall be unit mounted

B. Provide where specifically shown on the PLANS:
   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. Where available from the manufacturer, coat all printed circuit assemblies with a UL 746 recognized conformal coating.
   3. Auxiliary contacts rated for 120 volts A.C. Contacts shall satisfy the requirements of the PLANS.

2.05 COMBINATION UNITS

A. Each combination motor controller and feeder unit shall have the following characteristics:
   1. Molded case circuit breakers for branch circuit protection. Circuit breakers shall have the following characteristics:
      a. U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than that of the main bus.

b. Three pole, 600 volt, type and maximum continuous current carrying capacity as shown on the PLANS.

2. Starters shall have the following characteristics:
   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.
3. Provide Overload relays where required by the PLANS. Overload relays shall have the following characteristics:
   a. Standard class 20, ambient compensated,
   b. Manually reset by push-button located on front of the compartment door.
   c. Provide with auxiliary contact rated for 120 volts A.C. Contact shall satisfy the requirements of the PLANS.
   d. The overload relay heaters will be selected by the Contractor after delivery of the MCC. Include all necessary delivery, packaging, and administrative costs associated with the delivery of overload heaters.
4. Control Power Transformer. The transformer shall have the following characteristics:
   a. Adequately sized to serve all loads shown on the PLANS. Minimum size shall be as follows unless noted otherwise on the PLANS:
      1) NEMA Size 4 and larger starters: 750 VA
      2) All other starters, 200VA
   b. Connect as shown on the PLANS.
5. Provide one single pole fuse block with fuse for each motor space heater.
6. Where required by the PLANS, provide three phase power factor correction capacitor (PFCC) banks. Furnish and install additional requirements as follows:
   a. Manufacturer's standard overload protection for PFCC banks.
   b. Each PFCC bank is dedicated to correct the power factor of a specific pumping unit. The kVAR size/rating shown on the PLANS is a minimum requirement for bidding purposes. The manufacturer shall properly select the kVAR size/rating of the capacitor bank based upon the actual motor load data to ensure an improved operating power factor of greater than or equal to 95 percent (lagging) when the associated distribution pump motor load is in full operating condition. The PFCC banks shall be 480 volt rated PFCC banks.
   c. Connect as shown on the PLANS.
   d. Provide for auxiliary contacts as required by the PLANS. Contacts shall be rated for 120 volts A.C and shall satisfy the requirements of the PLANS.
7. Provide additional requirements as shown on the PLANS.
8. Variable Frequency Drives:
   a. Each variable frequency drive starter assembly shall include a NEMA rated main output contactor that is electrically interlocked with the VFD

controller and full voltage bypass starter as also shown in the PLANS. The VFD shall have a 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 Owner's existing distributed control system logic as shown on the PLANS. Provide supplementary control relays and interlocks as required for the proper interconnection and operation of the VFD with the Owner's existing distribution control system logic. Additionally, furnish the features as shown on the PLANS.

b. Each VFD shall be a 18-pulse 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. The VFD shall have an 18 pulse integrally mounted phase shifting transformer.
c. The use of harmonic filter traps, 6 pulse drives with harmonic filter traps, 12 pulse rectifiers with harmonic filter traps, active filters, or active converter sections shall not be accepted.
d. Each VFD shall be 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. The VFD section containing the VFD shall have a minimum of one (1) door mounted ventilation fan rated at 120VAC, thermostatically controlled, fused, and wired to the control power transformer, although it may not be shown on the PLANS. Ventilation fan to provide positive forced air ventilation of MCC section containing the VFD. Provide dedicated thermostat for each VFD. Furnish additional ventilation fans as required in accordance with VFD Manufacturer's recommendations to provide for proper VFD heat exchange.
g. The VFD section shall also be supplied with a high ambient temperature switch separate from the fan control thermostat to detect excessive VFD section temperature. Although it may not be shown on the PLANS, wire switch contacts to shut down the VFD and telemeter a common alarm to the Owner's existing distributed control system.
h. Each VFD shall be designed to operate in an ambient temperature from 0 to 40 degrees Celsius.
i. Each VFD shall be designed to operate from an input voltage of 480 plus or minus 15 percent VAC.
j. Each VFD shall operate from an input voltage frequency range of 60 Hz with plus or minus 2 percent.
k. The displacement power factor shall not be less than 0.975 lagging under any speed or load condition.
l. The efficiency of each VFD at 100 percent speed and load shall be greater than or equal to 95 percent.
m. The minimum continuous output current of the VFD shall be as shown on the one-line drawings in the PLANS.
n. The constant torque rated VFD overtorque capacity shall be 150 percent for 1 minute.
o. The variable torque rated VFD overtorque capacity shall be 110 percent for 1 minute.

p. The control logic drawings in the PLANS show the minimum requirements for the VFD. Furnish additional controller contact inputs/outputs, interposing relays, selector switch contacts, fused power supplies, etc., as required to facilitate VFD operation.
q. A digital terminal keypad shall be provided with each starter/controller for viewing of electrical values, configuration of parameters, I/O assignments, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics. The terminal keypad will consist of programmable function keys. The functions will allow both operating commands and programming options to be preset by the operator. The Keypad shall be rated NEMA Type 12 and be mounted to the face of the VFD.
r. Furnish and install VFD with harsh environment UL 746 recognized conformal coating for all printed circuit assemblies.
s. 18 pulse phase shifting transformer:
    1) Integrally mounted inside of the overall VFD enclosure
    2) High quality electrical grade steel core
    3) UL recognized 180 degree C insulation system with 150 degrees C temperature rise.
    4) Shall be provided with winding high temperature alarm contact interlocked with VFD control logic per the VFD manufacturer's standard practice.

2.06 SURGE PROTECTIVE DEVICE (SPD)

A. Provide Surge Protective Device system (SPD) were required by the PLANS. The SPD shall have the following characteristics:
    1. SPD shall be tested with the ANSI/IEEE Category C high exposure waveform of 10 kA for 8 x 20 microseconds, at minimum.
    2. Integrated surge protective device recognized in accordance with UL 1449.
    3. Minimum surge current withstand shall be 160 kA per phase (80 kA per mode)
    4. Has a minimum pulse life of 5000 ANSI/IEEE Category C high transients without failure or degradation of clamping voltage by more than 10 percent.
    5. Provide with manufacturer's standard line side disconnect.
    6. Provide visual indication of SPD status
    7. Surge counter.
    8. Provide dry contact failure status output contact. Contact shall be rated for 120 volts A.C. and shall satisfy the requirements of the PLANS.
    9. 5 year warranty, at minimum.

2.07 POWER MONITORING UNIT (PMU)

A. Where required by the PLANS, furnish and install a Power Metering Unit (PMU).
    1. The PMUs shall be as manufactured by General Electric - MULTILIN Model EPM 9700 (Transducer Module) with advanced software option complete with three line LED combination display and keypad Model P40NPLUS, with the Ethernet communication capability, harsh environment UL 746C/94 recognized conformal coating on all printed circuit assemblies and all required interconnect cabling as also shown on the PLANS, No Equal. Units shall be connected as shown on the PLANS.

2. Furnish and install an Ethernet connection to the PMU on the door adjacent to the LED display for accessing PMU settings files.

2.08 INSTRUMENT TRANSFORMERS

A. General
   1. All instrument transformers specified shall be installed and connected at the factory.

B. Instrument current transformers (C.T.'s):
   1. Provide current transformers where required by the PLANS. Connect as shown on the PLANS.
   2. Current transformers shall be the window type and shall have an ANSI 60 Hz Metering Accuracy Class of 0.3 measured at burden of B0.1, at minimum.
   3. Install a shorting terminal block for each current transformer (C.T.). Prewire all terminals of each C.T. to its respective shorting terminal block. Shorting terminal blocks shall be as manufactured by "G.E.", or approved equal.

C. Instrument Potential Transformers (P.T.'s):
   1. Provide potential transformers where required by the PLANS. Connect as shown on the PLANS.
   2. Potential transformers shall have the following characteristics:
      a. Primary voltage: 480 volts A.C.
      b. Secondary voltage: 120 volts A.C.
      c. Accuracy rating: 0.6 Y at burden of 1.2X
      d. Thermal Burden: 150 VA at 30 degrees C ambient
      e. Frequency: 60 Hz.
   3. Install with primary and secondary disconnect devices, grounding device, and accessories in conformance with IEEE and NEMA standards.
   4. Provide current limiting type primary fuses.

2.09 MISCELLANEOUS ACCESSORIES

A. Pilot Lights:
   1. Type: Transformer Type Light Emitting Diode (LED),
   2. Style: Push-to-test
   3. Lens Color: Furnish and install the colors as shown on the PLANS.
   4. Rating: NEMA 4/13, oil tight and water tight, Heavy Duty
   5. Size: NEMA Style full size 30-millimeter (30mm),
   6. Contacts: 10 ampere minimum at 120 volts A.C. Provide number of contacts to satisfy the requirements of the PLANS.
   7. Legend Plate: Furnish and install per manufacturer's standard with inscription as shown on the PLANS.
   8. Manufacturer: Allen Bradley Bulletin 800T, or approved equal.

B. Control relays shall have the following characteristics:
   1. 600 volts, standard NEMA Size, AC Heavy-Duty industrial type with 120 volt AC coils.
   2. Minimum contact rating of 10A, continuous, at 120 volts AC.

3. Furnish each relay with one additional Normally Open (N.O.) and one additional Normally Closed (N.C.) contacts over the number required by the PLANS.
4. Provide each relay with Relay Manufacturer's Transient Suppression Module.
5. Relays shall be "Allen Bradley Bulletin 700", Type-700P, or approved equal relays of the MCC manufacturer.

C. Timing Relays shall have the following characteristics:
1. Solid state, multi-time, and multi-function type relay
2. Both timing ranges and timing modes shall be field selectable. Each relay shall be capable of the following timing modes:
a. On Delay
b. Off Delay
c. One Shot
d. Repeat Cycle
e. Interval
3. Minimum relay contact rating shall be 10 amps, continuous, at 120 VAC.
4. Timing relays shall be Square D Class 9050 model No. JCK70 complete with Type NR61 Socket, or approved equal.

D. Elapsed Time Meters shall be the non-resettable type, and shall have cyclometric type reading at least to 9999.9 hours and at least to the nearest one-tenth of an hour. Elapsed time meters shall be as manufactured by Eagle Signal/Danaher Controls series HK410. Mount to the front of the MCC.

E. MCC Space Heater Control Power Transformer for the MCC, where required by the PLANS, shall have the following characteristics:
1. Minimum size as shown on the PLANS. Adjust size as needed to serve the space heater loads.
2. 120 volt AC grounded secondary
3. Connect as shown on the PLANS.
4. The space heater of each vertical section of the MCC shall be individually protected with a fuse mounted in the control power transformer compartment.
5. The space heater circuitry shall be thermostatically controlled by centrally located adjustable thermostat(s). Provide the quantity of thermostats necessary to serve the load of the space heater circuitry.

F. Provide control power transformer, fuses, power supplies, etc., and associated interconnect wiring as required to provide functional control power service to the circuit breaker trip circuitry for proper operation of circuitry, per manufacturer's standard.

G. Provide key interlocks where required by the PLANS.

H. Patch Panel: Where shown on the PLANS, provide a dedicated patch panel for termination of the Ethernet data highway (serial communication) cabling for each Motor Protective Relay/Power Monitoring Unit. Patch panels shall be two-port, surface mounted, fully enclosed type, Category 6, with RJ-45 connectors, as manufactured by "Panduit", Model Mini-Com #CBXJ2IW-A, with "Mini-Com TX6A" UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal. Secure patch panel to backpanel with screws. Ethernet patch cords shall be

furnished and installed between the patch panel and the respective power monitoring unit/protective relay per the requirements of Section 17600 “Distributed Control System”. Length of patch cords shall be such to have one full coil of slack cable at a minimum to reduce physical strain on cable termination.

I. 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.

2.10 HARMONIC FILTER

A. General:
   1. Furnish and install Harmonic Filters as required to meet the specified harmonic performance requirements associated with Variable Frequency Drive application as described in subsection 1.08.L, this Section of the Specifications.
   2. Each Harmonic Filter shall be a passive series connected low pass filter consisting of an inductor capacitor network.
   3. The Harmonic Filter shall be suitable for use with specified type of Variable Frequency Drive.
   4. Each Harmonic Filter shall be mounted complete with all accessories inside of the enclosure hereinafter specified.
   5. Each Harmonic Filter shall be suitably sized for its respective motor.
   6. The type of Harmonic Filter specified below reflects the minimum Harmonic Filter features for bidding purposes. The selection of the final size and type of the Harmonic Filter shall be determined following Bid Award. The proposed size and type of the Harmonic Filter will be reviewed after Bid Award during the shop drawing submittal review process. The Owner shall select the size and type of the Harmonic Filter that will provide the best compliance with the specified harmonic performance requirements and the manufacturer shall furnish and install the Harmonic Filter accordingly at No Additional Cost To The OWNER.

B. The harmonic filter shall meet the harmonic performance specification with a three percent phase voltage unbalance as defined in ANSI C-84.1-1995.

C. The filter shall be listed per UL-508.

D. Overload capability: 150 percent of full load current for one minute duration, with 10 percent reduction in nominal voltage for 1 minute duration.

E. All inductor windings and harmonic filter internal wiring shall be copper.

F. Enclosure:
   1. Where Harmonic Filters are shown on the PLANS to be mounted separately from the equipment:
      a. Rating: NEMA-4X rated
      b. Material: Type 316 Stainless Steel

c. Door: Hinged door with lockable door handle.

2. Otherwise, mount Harmonic Filters inside the respective packaged system control panel.

G. Manufacturer: MTE Corporation “Matrix AP Harmonic Filter”, or approved equal.

PART 3 EXECUTION

3.01 FACTORY INSPECTION AND TEST

A. Standard factory tests shall be performed on the equipment specified in this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards. The manufacturer shall provide certified copies of factory test reports prior to shipment of the equipment to the project site. Format and quantities of the test report shall be in accordance to Section 01300 and Section 01730 of the Contract Specifications.

3.02 FIELD INSTALLATION (BY CONTRACTOR)

A. Install per manufacturer’s instructions and recommendations. Install all required safety labels.

B. Perform manufacturer’s field services as previously specified.

C. 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.

D. Size, furnish and install the motor space heater fuses based on actual motor space heater load current.

3.03 FIELD TEST AND CHECKS

A. Verify proper rotation of all motor loads

B. Verify motor space heater circuits are operational..

C. The following minimum test and checks shall be made before energizing the MCCs. These tests shall be performed by a Factory Trained Field Technician (non sales type):

1. Thoroughly inspect the MCC.
2. Test for proper phasing of power connections. Additionally, check phasing across the MCCs and connecting tie feeders (as applicable) using phasing sticks.
3. Set, adjust, and test all protective relays based on the results of the coordination study, refer to sub-section 1.08, this Section of the Specifications.
4. Megger terminals and buses for grounds, test per manufacturer’s recommendations.
5. Verify ratios of all CT’s, and proper operation of all metering.
6. Verify MCC enclosure space heater circuits are operational.

7. Test key interlock system functionality
8. Check tightness of accessible bolted bus joints using calibrated torque wrench per manufacturer's recommended torque values.

D. Submit documentation of all tests outlined above.

E. Submit manufacturer’s certification report per sub-section 1.08, this Section of the Specifications.

3.04 EQUIPMENT PROTECTION AND RESTORATION

A. Clean and vacuum all interior of the equipment.

B. Touch-up and restore damaged surfaces to factory finish.

C. Energize the space heaters within the MCC and energize during storage and installation for humidity control.

3.05 TRAINING

A. Provide training sessions for owner’s representatives for Two (2) FULL normal workdays at the job-site location and/or at a location determined by the OWNER. If training is conducted in less than the time required by these specifications, the remaining time shall be utilized at the discretion of the OWNER.

B. The training session shall be conducted by the MCC manufacturer’s non-sales-type technical representative, who performed the field installation and start-up/setting/adjustment services.

C. At minimum, the training session shall include:
1. Operation and maintenance procedure for the equipment and all components installed within the MCCs.
2. Factory contact persons phone numbers, persons names, ordering procedures and procedures to follow to obtain meaningful results from the factory.
3. Potential of arc-flash hazards associated with working on energized equipment.

3.06 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 16121

MODIFICATIONS TO EXISTING 480 VOLT MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Scope of Work
   1. The Contractor shall furnish and install the modifications required to the Owner's existing motor control centers as specified herein and as shown on the PLANS.
   2. The existing motor control centers are vital to the Owner's waste-water treatment plant process system. Therefore, required interruptions to the plant process shall be minimized and carefully coordinated with the Owner. Regarding interruptions, refer to and comply with the General Notes shown on the Electrical PLANS.
   3. The arrangement and dimensions of the existing motor control centers are based on the data available and information provided by the Owner and based on site investigations. The Contractor shall also field verify all available data/information prior to commencement of the improvements required under this project. Should any deviation be found between the PLANS and the Contractor's site findings, it shall be brought to the attention of the Owner prior to Bid. Otherwise, it shall be assumed that conditions are as is and no additional, less, and/or departure of work is expected from what is shown on the PLANS and Specified herein.

1.02 RELATED WORK NOT INCLUDED

A. The PLANS designate the type, number, size and rating of devices included in the Motor Control Centers (MCCs)

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 in accordance with the requirements of Section 01300 of the Contract Specifications. Include:
   1. Dimensioned/scaled top and bottom views, front elevations, and internal component/device layouts
   2. One-line diagrams and wiring diagrams,
   3. Catalog cut sheets. Include protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves, where applicable.
   4. Key interlock scheme drawing and sequence of operations, where applicable.

1.04 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. Sealed and signed arc flash hazard analysis, harmonic study, motor starting, short circuit, and coordination study report. Report to include all final setpoints used.

B. Additional information as required by subsection 1.08, this section of the Specifications.

1.05 QUALITY ASSURANCE

A. All parts and distribution and control equipment required to modify the existing motor control centers shall be the product of the original manufacturer of the motor control centers and/or as recommended/approved by the original manufacturer of the motor control centers, NO EQUAL, for use in the existing Motor Control Centers, and as also called for on the PLANS and in compliance with this Section of the Specifications. Substitute manufacturers will not be accepted.

B. Modifications to the motor control centers shall be performed and tested in accordance with the latest applicable requirements of NEMA, ANSI, UL, and NEC standards. Modifications to the motor control centers shall be performed by qualified, experienced, manufacturer trained technical (non-sales type) representative, or Engineering Services Group trained technical (non-sales type) representative, or Original Equipment Manufacturer's trained technical (non-sales type) representative, by Siemens, Allen Bradley, Square-D Company, Asian Brown Boveri, Eaton Corporation, or approved equal.

C. In addition to these Specifications, refer to the PLANS for specific requirements on the Motor Control Centers.

1.06 STORAGE AND HANDLING

A. Protection
   1. The Contractor, and hence the MCC supplier, shall be responsible for safety of the MCC during storage, transporting and handling.
   2. Deliver, store, protect, and handle products in conformance with manufacturer's recommended practices as outlined in applicable Installation and Maintenance Manuals.
   3. Products shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment.
   4. At all times, store products inside a moisture free, non-porous, extra heavy duty plastic weatherproof housing.
   5. Interior and exterior of MCC shall be kept clean at all times.

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 one day 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.

1.07 TOOLS AND SPARE PARTS

A. Furnish the following spare parts with the equipment for each MCC in conformance with the specifications:
   1. One (1) – Set of fuses (minimum 3) for each type and size used.
   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. Two (2) - Contactor coils for every NEMA size and type starter installed, a minimum of one coil per size.
   4. Two (2) - Spare control relays for each type used. Control relay shall be furnished complete with relay coils, Four (4) Normally Open (N.O.) contacts, Four (4) Normally Closed (N.C.) contacts, and shall be furnished with Relay Manufacturer's Transient Voltage Suppression Module.
   5. One (1) - Spare timing relay.
   6. Two (2) – Sets of overload heaters for each size and type used.
   7. One (1) quart of manufacturer's standard touch-up paint.
   8. One (1) - Spare elapsed time meter for each motor control center in which an elapsed time meter is used.

1.08 SPECIAL MANUFACTURER SERVICES

A. Prepare an arc-flash study, harmonic study, and a coordination study, complete with short circuit calculations and coordination curves, etc. as required by and in compliance with Section 16120 of the Specifications "480 Volt Motor Control Centers", paragraph 1.08 "Special Manufacturer's Services".

B. Furnish the services of a qualified, experienced, factory trained technical (non-sales type) representative to assist in the installation of the equipment. Include checking alignment of parts, wiring connections, operation of all parts (relays, starters, monitoring relays, 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, adjusted, properly tested, and set in accordance with the manufacturer's recommendations and is in satisfactory operating condition. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications.

C. Manufacturer's technical representative is to set, adjust and test all protective relays, etc. in the presence of a representative of the Owner. The settings will be based on coordination and short circuit studies performed in compliance with Section 16120 of the Specifications "480 Volt Motor Control Centers", paragraph 1.08 "Special Manufacturer's Services". Provide the Owner with 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 of the Specifications. 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 at No Additional Cost to the Owner.

D. Any problems encountered with the operation of equipment, parts, components, etc. installed within the MCC line-up shall be repaired/remedied by the manufacturer's technical representative.

PART 2 PRODUCTS

2.01 GENERAL

A. For additional construction notes and special requirements, refer to the PLANS. Also refer and adhere to the requirements of the PLANS.

B. Motor Control Center shall not exceed the dimensions shown on the PLANS. Compartment/component arrangement shall be as shown on the elevation drawings. Provide for incoming feeder entering from below or above, and for outgoing circuits exiting from above and below, as shown on the PLANS.

C. The requirements described herein and as shown on the PLANS apply to any modification work to the MCCs including the relocating and/or modification of existing breaker/combination starter compartments, addition of combination starter compartments, addition of breaker only compartments, etc.

2.02 CONSTRUCTION

A. Structure
   1. Enclosures shall be NEMA Type 1, Gasketed. Enclosure shall be the totally enclosed, dead front, free standing type suitable for back-to-wall mounting.
   2. MCC shall consist of required number of vertical sections bolted together to form a rigid self supporting assembly. Each vertical section shall be nominally

90 inches high. Each vertical section shall be subdivided into compartments (units). Refer to the PLANS for additional dimensional requirements.

3. The MCC shall contain a top horizontal wireway and a bottom horizontal wireway running the full width of the MCC. The bottom horizontal wireway shall be covered by hinged doors. Each vertical section shall include a top plate and a bottom plate; plates shall be removable.
4. Each vertical section containing a plug-in unit shall also contain a vertical wireway that interconnects the top and bottom horizontal wireways. The vertical wireway shall be covered by a hinged door.
5. Each unit within each vertical section shall have a hinged door. Each unit shall have a padlockable disconnect operating handle. Include provisions for up to three padlocks. Handle shall be mechanically interlocked with the door to prevent personnel from opening the door when the unit disconnect is in the ON position. Provide handle-door interlock defeating (bypass) feature. Provide non-defeatable interlock to prevent the installation of a plug-in unit unless the unit disconnect is in the OFF position.
6. Unused unit spaces in each vertical section shall be covered by hinged blank doors and equipped to accept future units.
7. All combination starter and feeder units of plug-in construction shall utilize mechanical guides to insure positive alignment of the unit stabs to the section vertical bus. For each unit, shutters shall be provided to cover bus access openings when unit is removed. Unused structure openings shall have plugs or covers to prevent entry of foreign objects into the bus area.
8. Structure finish shall be primed and painted using the manufacturer's standard finishing process. Finish shall be applied at the manufacturing plant. Color shall be manufacturer's standard.
9. Provide each vertical section with an accessible space heater wired to terminal blocks in the respective section. Size the space heater per manufacturer's standard.
10. Structure shall include field removable lifting means.
11. Where an incoming line section is required by the PLANS, the Incoming Line Section shall include lugs for the connection of the field wiring shown on the PLANS.

B. Wiring
   1. Unless otherwise noted, the MCC shall be wired Class II, type B construction with terminal blocks for each cubicle.
   2. All control wiring shall be tin-plated stranded copper not smaller than #14.
   3. All wiring shall be neatly bounded with tie-wraps and supported to wire ways supports.
   4. Wiring shall be terminated to split-type terminal blocks.

C. Identification
   1. All component and control identification labels shall include the device name and number exactly as it appears on the PLANS. Refer to the PLANS.
   2. All control wires shall be tagged and coded with an identification number. Tagging type and wire coding shall be per manufacturer's standard.
   3. All terminal blocks shall be identified.
   4. Properly label the devices mounted inside each section using manufacturer's standard laminated labels installed in accordance with the manufacturer's standard method.

5. 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: Engraved through the face layer to the melamine middle layer. Nameplates located on the face of each section/compartment of each MCC shall be legible at a distance of six feet from the nameplate.
    d. Accessories: Provide holes for mechanical fastening
    e. Attachment Means: Secured with two Stainless Steel screws/bolts per manufacturer’s standard; use of adhesives shall not be accepted.
6. Furnish and install nameplates for:
    a. Each equipment/device/etc. installed/mounted on the face of the MCC.
    b. Each exterior section/compartment of each MCC.
    c. Overall entire lineup of MCC, i.e. a master nameplate. In addition to manufacturer’s standard information for master nameplates, Master nameplate shall include, at minimum, the tag of the MCC as shown on the PLANS and all information required by the NEC.

2.03 MAIN AND TIE CIRCUIT BREAKERS

A. Rating: Circuit breaker shall be three pole, 600V with a maximum continuous current carrying capacity shown on the PLANS and a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than 42,000 amperes at 480V A.C. Breaker shall be U.L. listed and comply with NEMA Standard No. AB1-1975 and Federal Specification W-C-3758/GEN 21a. Circuit breaker shall be fully rated and not require rating for ambient temperatures 40 degrees Celsius or less.

B. Circuit breaker shall be furnished with solid state type electronic trip attachment. The attachment shall have the following minimum features:
    1. Alpha-numeric display
    2. Circuit breaker test receptacle
    3. Field adjustable settings:
        a. Long time pickup
        b. Long time delay
        c. Short time pickup
        d. Short time delay
        e. Instantaneous pickup
        f. Ground fault pickup
        g. Ground fault delay
    4. Where available from the manufacturer, coat all printed circuit assemblies with a UL 746 recognized conformal coating.

C. Circuit breaker shall be fixed mounted power operated. The breaker shall be operated by an electric motor operator, remotely operated from the Distributed Control System, and in an emergency by a manual handle. The breaker shall include a provision for padlocking open to prevent manual or electric closing. The padlocking shall also secure the breaker in the connected test, or disconnect

position by preventing levering. The circuit breaker shall be manufactured by "Siemens" model "ND Series" or approved equal.

D. The circuit breakers shall be furnished with the following accessories and options:
   1. Alarm switch to energize an Owner furnished warning device. Alarm switch contact shall close when the circuit breaker trips open. Wire alarm contact to terminal blocks for Owner use as shown on the PLANS.
   2. Auxiliary switch equipped with one normally open contact and one normally closed contact to provide remote ON or OFF indication. The auxiliary switch shall activate when the circuit breaker trips open. Wire both contacts to terminal blocks for Owner use as shown on the PLANS.
   3. Electric motor operator designed to open, close and reset the circuit breaker by remote control. The electric motor operator shall have the following minimum features:
      a. Compatible with Siemens Type ND breaker frame
      b. Operating Voltage: 120 VAC
      c. Operating Current:
         1) 13.2 Amperes Running
         2) 30.2 Amperes In-Rush
      d. Operating Time:
         1) On: 240 msec.
         2) Off: 210 msec.
      e. Manufacturer: Electric motor operator shall be Telemand® Motor Operator catalog number EMOPL120MN as manufactured by Siemens, or approved equal.

E. The 120VAC source for each MAIN and TIE circuit breaker shall be supplied from a dedicated control power transformer internal to the MCC assembly and connected to the line side of the circuit breaker terminals. The control power transformer(s) shall be provided with fused primary windings and fused secondary windings as specified hereinafter. The Manufacturer shall size the control power transformer, fuses and related interconnect wiring.

F. Provide each circuit breaker with the components required to comply with the Main and Tie Circuit Breaker Control Wiring Schematics shown on the PLANS.

G. Terminations: Breakers shall have removable lugs, U.L. listed for copper and aluminum conductors and U.L. listed for installation of mechanical screw type lugs.
   1. Lugs shall be able to accept the quantity of parallel conductors per phase and the size conductor shown on the PLANS. Refer to the PLANS.

2.04 BRANCH FEEDER CIRCUIT BREAKERS

A. Provide thermal magnetic molded case circuit breakers with the following minimum requirements:
   1. U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than that of the main bus.
   2. Circuit breaker shall be three pole, 600 volt with a maximum continuous current carrying capacity shown on the PLANS.

3. 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.
4. 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. The design shall provide common tripping of all poles. Breakers shall be suitable for reverse feeding.
5. Provide complete with rating plug and other accessories as required for proper operation of circuit breaker.
6. Provide mechanical padlock attachment for each circuit breaker.
7. Furnish lugs for feeders where required to facilitate field wiring termination, sizes shall be as required by the PLANS.
8. All circuit breakers shall be unit mounted

B. Provide where specifically shown on the PLANS:
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. Where available from the manufacturer, coat all printed circuit assemblies with a UL 746 recognized conformal coating.
3. Auxiliary contacts rated for 120 volts A.C. Contacts shall satisfy the requirements of the PLANS.

2.05 COMBINATION UNITS

A. Each combination motor controller and feeder unit shall have the following characteristics:
1. Molded case circuit breakers for branch circuit protection. Circuit breakers shall have the following characteristics:
a. U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than that of the main bus.
b. Three pole, 600 volt, type and maximum continuous current carrying capacity as shown on the PLANS.
2. Starters shall have the following characteristics:
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.
3. Provide Overload relays where required by the PLANS. Overload relays shall have the following characteristics:
a. Standard class 20, ambient compensated,
b. Manually reset by push-button located on front of the compartment door.
c. Provide with auxiliary contact rated for 120 volts A.C. Contact shall satisfy the requirements of the PLANS.

d. The overload relay heaters will be selected by the Contractor after delivery of the MCC. Include all necessary delivery, packaging, and administrative costs associated with the delivery of overload heaters.

4. Control Power Transformer. The transformer shall have the following characteristics:
   a. Adequately sized to serve all loads shown on the PLANS. Minimum size shall be as follows unless noted otherwise on the PLANS:
      1) NEMA Size 4 and larger starters: 750 VA
      2) All other starters, 200VA
   b. Connect as shown on the PLANS.
5. Provide one single pole fuse block with fuse for each motor space heater.
6. Where required by the PLANS, provide three phase power factor correction capacitor (PFCC) banks. Furnish and install additional requirements as follows:
   a. Manufacturer's standard overload protection for PFCC banks.
   b. Each PFCC bank is dedicated to correct the power factor of a specific pumping unit. The kVAR size/rating shown on the PLANS is a minimum requirement for bidding purposes. The manufacturer shall properly select the kVAR size/rating of the capacitor bank based upon the actual motor load data to ensure an improved operating power factor of greater than or equal to 95 percent (lagging) when the associated distribution pump motor load is in full operating condition. The PFCC banks shall be 480 volt rated PFCC banks.
   c. Connect as shown on the PLANS.
   d. Provide for auxiliary contacts as required by the PLANS. Contacts shall be rated for 120 volts A.C and shall satisfy the requirements of the PLANS.
7. Provide additional requirements as shown on the PLANS.

2.06 MISCELLANEOUS ACCESSORIES

A. Pilot Lights:
   1. Type: Transformer Type Light Emitting Diode (LED),
   2. Style: Push-to-test
   3. Lens Color: Furnish and install the colors as shown on the PLANS.
   4. Rating: NEMA 4/13, oil tight and water tight, Heavy Duty
   5. Size: NEMA Style full size 30-millimeter (30mm),
   6. Contacts: 10 ampere minimum at 120 volts A.C. Provide number of contacts to satisfy the requirements of the PLANS.
   7. Legend Plate: Furnish and install per manufacturer's standard with inscription as shown on the PLANS.
   8. Manufacturer: Allen Bradley Bulletin 800T, or approved equal.

B. Control relays shall have the following characteristics:
   1. 600 volts, standard NEMA Size, AC Heavy-Duty industrial type with 120 volt AC coils.
   2. Minimum contact rating of 10A, continuous, at 120 volts AC.
   3. Furnish each relay with one additional Normally Open (N.O.) and one additional Normally Closed (N.C.) contacts over the number required by the PLANS.
   4. Provide each relay with Relay Manufacturer's Transient Suppression Module.

5. Relays shall be “Allen Bradley Bulletin 700”, Type-700P, or approved equal relays of the MCC manufacturer.

C. Timing Relays shall have the following characteristics:
   1. Solid state, multi-time, and multi-function type relay
   2. Both timing ranges and timing modes shall be field selectable. Each relay shall be capable of the following timing modes:
      a. On Delay
      b. Off Delay
      c. One Shot
      d. Repeat Cycle
      e. Interval
   3. Minimum relay contact rating shall be 10 amps, continuous, at 120 VAC.
   4. Timing relays shall be Square D Class 9050 model No. JCK70 complete with Type NR61 Socket, or approved equal.

D. Elapsed Time Meters shall be the non-resettable type, and shall have cyclometric type reading at least to 9999.9 hours and at least to the nearest one-tenth of an hour. Elapsed time meters shall be as manufactured by Eagle Signal/Danaher Controls series HK410. Mount to the front of the MCC.

E. MCC Space Heater Control Power Transformer for the MCC, where required by the PLANS, shall have the following characteristics:
   1. Minimum size as shown on the PLANS. Adjust size as needed to serve the space heater loads.
   2. 120 volt AC grounded secondary
   3. Connect as shown on the PLANS.
   4. The space heater of each vertical section of the MCC shall be individually protected with a fuse mounted in the control power transformer compartment.
   5. The space heater circuitry shall be thermostatically controlled by centrally located adjustable thermostat(s). Provide the quantity of thermostats necessary to serve the load of the space heater circuitry.

F. Provide control power transformer, fuses, power supplies, etc., and associated interconnect wiring as required to provide functional control power service to the circuit breaker trip circuitry for proper operation of circuitry, per manufacturer’s standard.

G. Provide key interlocks where required by the PLANS.

PART 3 EXECUTION

3.01 FACTORY INSPECTION AND TEST

A. Standard factory tests shall be performed on the equipment specified in this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards. The manufacturer shall provide certified copies of factory test reports prior to shipment of the equipment to the project site. Format and quantities of the test report shall be in accordance to Section 01300 and Section 01730 of the Contract Specifications.

3.02 FIELD INSTALLATION (BY CONTRACTOR)

A. Perform Motor Control Center modifications in accordance with manufacturer's written guidelines, the NEC, and local codes.

B. Refinish all painted steel work that was damaged during Motor Control Center modification activities. Finish shall match the existing Motor Control Center.

C. Install all required safety labels.

D. Perform manufacturer's field services as previously specified.

E. 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.

F. Size, furnish and install the motor space heater fuses based on actual motor space heater load current.

3.03 FIELD TEST AND CHECKS

A. Verify proper rotation of all motor loads

B. Verify motor space heater circuits are operational..

C. The following minimum test and checks shall be made before energizing the MCCs. These tests shall be performed by a Factory Trained Field Technician (non sales type):
   1. Thoroughly inspect the MCC.
   2. Test for proper phasing of power connections.
   3. Set, adjust, and test all protective relays based on the results of the coordination study, refer to sub-section 1.08, this Section of the Specifications.
   4. Megger terminals and buses for grounds, test per manufacturer's recommendations.
   5. Verify MCC enclosure space heater circuits are operational.
   6. Test key interlock system functionality

D. Submit documentation of all tests outlined above.

E. Submit manufacturer's certification report per sub-section 1.08, this Section of the Specifications.

3.04 EQUIPMENT PROTECTION AND RESTORATION

A. Clean and vacuum all interior of the equipment.

B. Touch-up and restore damaged surfaces to factory finish.

C. Energize the space heaters within the MCC and energize during storage and installation for humidity control.

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

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. Refer to the conduit/wire schedule shown on the PLANS for a listing of proposed raceways and other requirements. The conduit/wire schedule shown on the PLANS is not inclusive of all equipment required by this Contract. Refer to Part 2 of this section for additional requirements.

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, fittings 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 and Fiberglass conduit.
2. Submit 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 bolt-on type and shall have Type 316-Stainless Steel screws/hardware.
   2. 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.
   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: O.Z./Gedney Type EXPB-A, 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 Scotchcast Reenterable Electrical Insulating Resin 2123 as manufactured by "3M", or approved equal.
      c. Coordinate application with the Owner.
      d. For vertical seals use mineral wool packing material to form a dam in the annular space around the conductors and hold the sealing compound in place while it cures. Packing material shall be as manufactured by "Crouse-Hinds" type Chico-X, 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 “Prime Conduit”, 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 H_2O 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, or Plasti-Bond REDH_2OT.

D. Reinforced Thermosetting Resin Conduit (RTRC) Conduit System
   1. General:
      a. May be used only where specifically permitted by subsection 3.02.C.8, this Section of the Specifications.
      b. Shall comply with NEC Article 355.
   2. Material:
      a. Fiberglass, Reinforced Thermosetting Resin Conduit. Resin system shall be epoxy based, with no fillers, using an anhydride curing agent. The fiberglass shall consist of continuous E-glass Grade “A” roving. Conduit shall be low-halogen per UL 2515.
      b. Manufactured using the single circuit filament winding process. Oven cured. Nominal winding angle of 54.75 degrees.
      c. Carbon black shall be used as ultra violet inhibitor.
      d. Internal walls shall be smooth with all fibers embedded in epoxy.
   3. Certifications: NEMA TC14, UL 2420 and 2515.
   4. Suitable for installation exposed outdoors and encased in concrete
   5. Fittings:
      a. The following fittings shall be provided. Example part numbers shown hereinafter apply to the raceway system manufacturer specified hereinafter. All part numbers required for this project are not shown. Contractor to coordinate necessary part numbers with the manufacturer for a complete installation.
      b. 90 degree bends with factory installed 2 deep socket PVC coupling and 1 fiberglass coupling bonded to elbow:
         1) For conduit sized 1” – 1 ½”, provide type IPS. Example part number for 1”: 10C-XW-90-2DF
         2) For conduit sized 2” – 6”, use type ID. Example part number for 2”: 20D-XW-90-2DF
      c. Sleeve couplings:
         1) For conduit sized 1” – 1 ½”, use type IPS. Example part number for 1”: 10C-XW-42

2) For conduit sized 2” – 6”, use type ID. Example part number for 2”: 20D-XW-42

d. Female Terminal Adapters:
1) For conduit sized 1” – 1 ½”, use type IPS. Example part number for 1”: 10C-XW-32
2) For conduit sized 2” – 6”, use type ID. Example part number for 2”: 20D-XW-32

e. Straight Socket Conduit:
1) For conduit sized 1” – 1 ½”, use type IPS. Example part number for 1”: 10C-XW-10S
2) For conduit sized 2” – 6”, use type ID. Example part number for 2”: 20D-XW-20-S

6. Mix Epoxy Adhesive:
a. For ambient temperatures 40 - 70 degree F, provide type CM-2040-SFG
b. For ambient temperatures 70 degree F and above, provide type CM-2070-SFG.

7. Mix Epoxy Adhesive Mixing Tip and Gun:
a. Mixing Tip: CM-MT
b. Mixing Gun: CM-AG

8. Accessories: Provide with adhesive couplings, spigots, adapters, and other adhesive fittings as required to connect to the other specified raceways as shown on the PLANS.

9. Manufacturer: Champion Fiberglass “Haz Duct XW”, no equal.

2.03 LIQUID TIGHT FLEXIBLE CONDUIT

A. Sizes: - Greater than or equal to ¾ 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 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 ¾-inch unless specifically noted otherwise on the PLANS. Exception: ½” non-metallic conduit may be used for the final conduit connection to device with ½” threaded opening with prior Owner approval.

2.04 MISCELLANEOUS

A. Polyurethane foam duct sealant: FST-250 and FST-MINI Duct Sealant as manufactured by “Polywater”, 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).

D. Conduit Hole Seals:
   1. Hole seals shall be stainless steel, U.L. listed as NEMA 4X oil-tight, complete with oil-resistant gasketing, backplate, stud and wing nut. Hole seals shall be manufactured by Hoffman, Rittal, Cooper B-Line, or approved equal.

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. Anchors located in all areas:
      a. Type 316-Stainless Steel. Anchors shall also be per Section 05051 “Anchorages”.
   2. Also refer to the PLANS.

2.06 MANHOLES AND HANDHOLES

A. Refer to the 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.

D. The manhole structural wall opposite each duct bank penetration into the manhole shall be equipped with a cable pulling eye (one cable pulling eye per each duct bank penetration into the manhole). Position each pulling eye with coordinates (vertical elevation and horizontal alignment) to accommodate cable pulling and minimize cable pulling tension. Pulling eyes shall be bonded to the manhole wall structural reinforcement prior to pouring concrete. Pulling eyes may not be shown on the manhole vault structural PLANS, however, they are to be installed per the requirements of this specification.

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.

C. Contractor shall be trained and certified by the Fiberglass conduit manufacturer in the proper installation of the Fiberglass 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. 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.

C. 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. Reinforcing Steel shall be per Section 406S "Reinforcing Steel" unless noted otherwise on the PLANS. Also, refer to conduit/duct bank reinforcement and concrete encasement details shown on the PLANS.
   4. Install detectable underground warning tapes at 12-inches below finished grade along the entire length of each duct bank. Each tape shall be a minimum of 6-inches wide, 4 mil thick, laminated, and contain a aluminum foil core backing. The tape shall be detectable using a non-ferrous locator. The tape color shall be red and shall be labeled with the words "CAUTION BURIED ELECTRIC LINE BELOW" in black lettering. For duct banks less than 24-inches wide, install one length of tape aligned along the centerline of the duct bank. For duct banks 24-inches wide and larger, install two lengths of tape, with each length aligned with each edge of the duct bank along the width of the duct bank. Warning tape is not required along the length of the specific portion of a duct bank that is installed underneath a building concrete floor slab.
   5. 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.
   6. 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. Increase the minimum duct bank depths below finished grade as shown on the PLANS. 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.
   7. All underground conduit joints shall be watertight in accordance with the manufacturer's recommendations.
   8. Transition from underground (underground work in duct bank) to above ground conduit as shown on the PLANS.
   9. 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.

10. Where PVC coated rigid galvanized steel conduit is shown on the PLANS, Contractor may employ RTRC conduit in lieu of the PVC coated rigid galvanized steel conduit.
11. Where factory bends/elbows (11-1/4°, 22-1/2°, 30°, 45°, and 90°), as specified in Part 2.02 A 2 of this Specification, are not manufactured and field bends become necessary, field bends may be performed using a heat box type electric PVC conduit heater. The use of open flame to heat the PVC conduit is NOT permitted. Utilize a PVC conduit plug set to plug the ends of the conduit throughout the heating process and trap the air inside the conduit to help keep the PVC conduit from collapsing while forming the bend.

D. 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.
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.

E. Miscellaneous:
1. Seal empty spare conduits (at above ground stub-ups) with an aluminum screw in plug sized to the trade size of the conduits.
   a. Threaded insert plug shall have a square head and shall be constructed from copper-free Aluminum material.
   b. Threaded insert plug shall be Type CUPX by Hubbell-Killark, Type PLG by Crouse-Hinds, or approved equal.
2. Seal and pack/fill ends of each conduit with polyurethane foam duct sealant.
3. In all sealing fittings, utilize sealing compound to seal around and between each conductor and associated sealing fitting body.

F. 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.

G. 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 36-inches, unless specifically noted otherwise on the PLANS or approved by the 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. Use 316 stainless steel split ring lock washers with mounting hardware when installing support channels.

B. Whenever support channels are cut in the field, the cut ends shall be filed smooth and shall be cleaned using liberal amounts of a contact cleaner to remove all residual elements from the cutting and filing process. Coat all field cut ends with cold galvanizing paint.

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

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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 apply in whole to the installation of the fiber-optic cables and Ethernet copper cables. Fiber optic cables 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	----------
Ground	Green	Green	Green
Motor Space Heater (H)	----------	Black	----------
DC (+)	----------	----------	Blue
DC (-)	----------	----------	Brown

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 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.

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: White.
      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 ClearGlide, 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. Submersible Splice Connectors
   1. Use only where indicated on the PLANS for submersible applications of 600V and below power and control wiring terminations.
   2. 600V rated
   3. Manufactured from high strength 6061-T6 aluminum alloy
   4. Encapsulated in rubber with a nominal thickness of 125 mils. And high dielectric strength.
   5. Suitable for use with aluminum and copper conductors
   6. U.L. 486D Listed
   7. Manufacturer: “Polaris Connectors” Series ISPBS Submersible Splice Connectors and Series ISPB2/0 and ISPBO2/0 Submersible Streetlight Connectors, or approved equal.

E. 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 repellant 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 2.06.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 2.06.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 the 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, e.g.; 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 prior to application, the Owner has the discretion to limit application. For bidding purposes, the minimum 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 splice connectors, compression connectors, multi-cable 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 Multi-conductor Cable:

1. All single conductor control and instrument wiring (in Multi-conductor 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 multi-conductor 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 Multi-conductor 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 Multi-conductor Cable:
1. In addition to tagging each single conductor in a multi-conductor cable (as described in 3.03 B, above), the overall jacket of each multi-conductor 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 multi-conductor 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

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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 National Electrical Code (NEC), 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.
      a. Boxes shall have a smooth, non-brushed finish.
   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.
c. Boxes shall have a smooth, non-brushed finish.

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. Boxes or cabinets shall be not less than 6-inches deep and their minimum height and width dimensions shall be determined by the requirements of, and in compliance with the NEC.

C. Each type of box and cabinet on the project shall be manufactured by a single manufacturer.

D. 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 namplates.
   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

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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. Installed indoors inside the environmentally and climate controlled ELECTRICAL ROOMS:
   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.

B. Installed indoors inside STORAGE ROOMS and PROCESS MECHANICAL EQUIPMENT ROOMS and installed in ALL OUTDOOR AREAS:
   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. Factory-sealed where each switch is enclosed in a unique sealing well with double flanges that mate with the light switch cover and box assembly.
5. Raintight, corrosion resistant and rated for use in wet locations and in Class I Division 2 hazardous areas (as classified by NEC).
6. Manufacturer: Cooper Crouse-Hinds, Killark, or approved equal.

C. Box: Provide as hereinafter specified.

2.02 120 VOLTS AC, COVENIENCE RECEPTACLES

A. Installed indoors inside the environmentally and climate controlled ELECTRICAL ROOMS:
1. Receptacle
   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.
2. Ground Fault Interrupter Receptacle:
   a. Provide where G.F.I receptacles are indicated on the PLANS
   b. Specification grade, weather-resistant type,
   c. Duplex, 3-wire, polarized grounding type, rated 20 amp, 125 volt, 60 Hertz.
   d. Red indicator light
   e. Test and Reset pushbutton
   f. Ivory color.
   g. Manufacturer: Pass & Seymour Cat. No. 2095TRWR, or approved equal.
3. Box: Provide as hereinafter specified.

B. Installed indoors inside STORAGE ROOMS and PROCESS MECHANICAL EQUIPMENT ROOMS and installed in ALL OUTDOOR AREAS:
1. Specification grade
2. 2-wire, 3-pole, rated 20 amp, 120 volt,
3. Twist-lock, factory-sealed, pin and sleeve
4. Internal horsepower and AIC-rated switch that shall activate only after the Plug is inserted into the receptacle and twisted.
5. Dead-front, mechanically interlocked where plug cannot be engaged or disengaged under load.
6. Brass receptacle blades/contacts
7. Watertight, raintight and corrosion resistant and rated for use in Class I Division 2 hazardous areas.
8. Fully gasketed, watertight, dustight and corrosion resistant twist-on cover.
9. Type 12 nylon enclosure with 316 stainless steel hardware
10. Manufacturer: Cooper Crouse-Hinds Series IEC-309 Hazardous Area Receptacles/Plugs and Interlocks, Factory-Sealed, TYPE GHG Pin and Sleeve receptacles complete with device boxes and specified accessories.

11. Furnish and install a total count of Two (2) Sets of completely assembled matching CORD and PLUG assembly for the Pin and Sleeve Receptacles. The cord and plug assembly (of each set) shall consist of:
    a. Matching Male Plug manufactured by Cooper Crouse-Hinds Series IEC-309 Hazardous Area Plugs and Interlocks, Factory-Sealed, TYPE GHG Pin and Sleeve Twist-On plug
    b. 25-feet of #12AWG, 3-conductor extra-flexible Type SO-CORD power cord (each conductor shall be 100%-conductive-soft-copper conductors with 41-strands).
    c. NEMA 5-20R Female Connector, 20-amp, 125 volt rated having tin-plated-copper spade-connectors.

2.03 DEVICE ENCLOSURES AND COVERPLATES

A. Installed indoors inside the environmentally and climate controlled ELECTRICAL ROOMS:
    1. Enclosures for exposed surface mounted devices:
        a. Sand Cast Aluminum, 99.0% copper-free, one piece construction, suitable for surface mounting
        b. Single and Multi-Gang Weatherproof Outlet boxes, as required.
        c. 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.
        d. Manufacturer: Crouse-Hinds Series FS or FD, Appleton, or approved equal.
    2. Coverplates:
        a. 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.
        b. Receptacles: Die Cast Aluminum 99.0% copper-free, complete with rubber gasket, as manufactured by Crouse-Hinds WLRS (single cover), WLRD (duplex cover), WLGF-FS and WLGF-FSV (GFCI cover) or approved equal.

B. Installed indoors inside STORAGE ROOMS and PROCESS MECHANICAL EQUIPMENT ROOMS and installed in ALL OUTDOOR AREAS:
    1. Enclosures:
        a. Sand Cast Aluminum, 99.0% copper-free, one piece construction, suitable for surface mounting
        b. Single and Multi-Gang Weatherproof Outlet boxes, as required.
        c. 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.
        d. Manufacturer: Crouse-Hinds Series FS or FD, Appleton, or approved equal.
    2. Coverplates:
        a. Switches: Die Cast Aluminum, 99.0% copper-free, watertight and corrosion resistant and having an external front operator (for snap switches). In a group installation, provide manufacturer's assemblies for two gang tandem, three, four and/or five gang bodies (device boxes). Light switch covers shall be as manufactured by Crouse-Hinds, Killark, or approved equal.
        b. Receptacles: See Part 2.02 B this Section of the Specifications.

2.04 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 (e.g. for panel “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.

B. Refer to the lighting fixture schedule shown on the PLANS for a listing of proposed lighting fixtures and other requirements. The lighting fixture schedule shown on the PLANS is not inclusive of all equipment required by this Contract. Refer to Part 2 of this section for additional requirements.

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 LED lamp modules: Five percent spare LED lamp modules for each fixture type specified, with minimum of 3 lamp modules of each type.
   2. Spare Drivers: Five percent spare drivers for each fixture type specified, with minimum of 6 drivers of each type.
   3. Spare Ballasts: Five percent spare ballasts for each fixture type specified, with minimum of 6 ballasts of each type.

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, hickeys, 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 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. 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 for photocell mounting as specified in Section 16300 "Wiring Devices". Orient and make wiring connections to photocell per photocell manufacturer's recommendations.

H. Lighting fixtures shall not be used as raceways for conductors that do not supply the connected fixtures.

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 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 - 1.05 (NOT USED)

1.06 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. Include:
   1. Copies of the approved shop drawings
   2. Factory and on-site/field test data.

1.07 (NOT USED)

1.08 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 climate controlled (temperature and humidity, etc.) environment. Use heat lamps as necessary to prevent condensation.

1.09 - 1.10 (NOT USED)

1.11 ACCEPTABLE MANUFACTURER

A. General Use (Power & Lighting) Dry-Type Ventilated Isolation Transformers shall be Watchdog Premium Quality units manufactured by Square D (Schneider Electric) class 7400, 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:

Transformer KVA Range	Sound Level
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

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.

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 - 1.05 (NOT USED)

1.06 SUBMITTALS

A. Submit Shop Drawings in accordance with Section 01300 of the Specifications. For each individual Panelboard include:
   1. Panelboard dimensions
   2. Ratings
   3. Branch circuit breaker schedules
   4. Main circuit breakers size
   5. Protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves
   6. Transformer impedance, where applicable

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Specifications. Include:
   1. Copies of the approved shop drawings
   2. On-site/field test data.

1.07 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.

1.08 DELIVERY, STORAGE, HANDLING, AND TOOLS

A. Deliver, receive, unload and handle equipment by suitable methods. Store in climate controlled (temperature and humidity, etc.) environment in original packaging, or, in protective plastic wrapping.

B. Provide breaker test set for Solid-State-Trip units for each type used.

1.09 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:
   1. Square D Company Series I-LINE with specified accessories. Approved equal Panelboards manufactured by Eaton Cutler-Hammer or Asea Brown Boveri are acceptable as equals.

C. 208/120 volts A.C., 3-phase, 4-wire Panelboards:
   1. Eaton Cutler-Hammer Corporation Type POW-R-Line 3a with specified accessories. Approved equal Panelboards manufactured by Square-D Company or Asea Brown Boveri are acceptable as equals.

1.10 SPECIAL MANUFACTURER'S SERVICES

A. Prepare an arc-flash study, harmonic study, and a coordination study, complete with short circuit calculations and coordination curves, etc. as required by and in compliance with Section 16120 of the Specifications "480 Volt Motor Control Centers", paragraph 1.08 "Special Manufacturer's Services".

B. Manufacturer's technical representative is to set, adjust and test all protective relays, etc. in the presence of a representative of the Owner. The settings will be based on coordination and short circuit studies performed per subsection 1.10.A, this Section of the Specifications. Provide the Owner with 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 of the Specifications. 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 at No Additional Cost to the Owner.

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 all 208/120 volts A.C., 3-phase, 4-wire Panelboards served from shielded ultra-isolation transformers, furnish a second tin-plated isolated ground bar in addition to the equipment ground bar. The isolated ground bar 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 Power Distribution Panelboards and Main Circuit Breakers in 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 Asea Brown Boveri, Eaton Cutler-Hammer Corporation.

b. 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 Asea Brown Boveri, Eaton 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 PLANS.

2.02 CABINET

A. Adhere to the requirements of UL 50.

B. Panelboard assemblies installed indoors:
   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. 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.

D. 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. Enclosures shall have a smooth, non-brushed finish.

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 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 16524

480 VOLT AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install the 480 Volt Automatic Transfer Switch (ATS) as specified herein and as shown on the PLANS.

1.02 RELATED WORK NOT INCLUDED

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 QUALIFICATIONS

A. The ATS shall be designed, constructed, and tested in accordance with the latest applicable requirements of NEMA, ANSI, U.L., and NEC standards.

B. All ATS's on the project shall be manufactured by a single ATS manufacturer.

C. The ATS shall be as manufactured by "Automatic Switch Company-ASCO, Model 7000" or Russelectric Inc, No Equal.

1.04 SUBMITTALS

A. Submit Shop Drawings in accordance with Section 01300 of the Specifications. Submittals shall include:
   1. Dimensioned/scaled top and bottom views, front elevations, and internal component/device layouts
   2. One-line and wiring diagrams,
   3. Catalog cut sheets

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. Also, as minimum the Operations and Maintenance Manuals shall include:
   1. Copies of certified and approved shop drawings.

2. Detailed information on each component used, including:
    a. Installation and operation manual.
    b. Renewal parts bulletin.
    c. As built drawings, including approved shop drawings.
    d. Test data.
    e. Detailed transfer switch setting parameters, DIP-switch settings, ranges, options, operating setting and calibrating instructions, etc.

1.05 STORAGE AND HANDLING

A. Protection
    1. The CONTRACTOR, and hence the ATS supplier, shall be responsible for safety of the ATS during storage, transporting and handling.
    2. The ATS shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment.
    3. At all times the ATS shall be housed inside a moisture free, non-porous, extra heavy duty plastic weatherproof housing.
    4. Interior and exterior of the ATS shall be kept clean at all times.
    5. Size, furnish and install temporary space heaters within the ATS 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, 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.

1.06 SPARE PARTS

A. One (1) quart of touch up paint.

PART 2 PRODUCT

2.01 AUTOMATIC TRANSFER SWITCHES (ATS) REQUIREMENTS AND UNIT DESCRIPTION

A. General:
1. ATS shall be completely factory interconnected, pre-wired and tested.
2. ATS mechanism shall be of the electrically operated, double throw mechanically held type, actuated by a single solenoid operator momentarily energized to assure quiet operation.
3. ATS shall be inherently interlocked, mechanically in either normal or emergency position with no “OFF” position possible. Gravity or spring operated switches will not be acceptable. ATS shall be the “open transition” type of automatic transfer switch.
4. All main contacts shall be provided with silver alloy material for high conductivity under all conditions of service. The ATS shall be suitable for all classes of loads, including inductive loads, resistive loads, control loads, and electrical discharge and tungsten-filament loads.
5. Inspection of contacts shall be possible from the front of the switch.
6. A manual operating handle shall be provided.
7. The ATS shall have a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than the minimum RMS symmetrical short circuit current rating shown on the PLANS. The ATS contacts rating and number of poles shall be as shown on the PLANS (electrical one line diagrams).
8. The ATS shall be furnished complete with the automatic transfer control system.
9. The ATS, automatic control transfer system, sensors, timers, etc. shall be mounted, as one unit, in a single enclosure as specified hereinafter. The ATS shall be mounted where shown on the PLANS.

2.02 AUTOMATIC TRANSFER SWITCH (ATS) CONTROL REQUIREMENTS

A. General:
1. The ATS shall automatically transfer power from one power source to another, in the event of normal/primary power source failure, one primary feeder failure, etc. The ATS shall ensure continuity of the load circuit power supply for as long as one of the two primary feeders to the ATS is active. The ATS shall also include functionality to initiate transfer of power from one source to another based upon discrete commands received from the Owner’s Distributed Control System, as also shown on the PLANS.

B. Voltage and frequency sensing:
1. Provide field adjustable setpoints with the following Dropout and Pickup ranges for the following parameters:

Parameter	Source	Dropout Range	Pickup Range
Undervoltage	Normal and Emergency	70% – 98%	85% - 100%
Underfrequency	Normal and Emergency	85% - 98%	90% - 100%
Voltage Unbalance	Normal and Emergency	5% - 20%	2% below dropout

C. Transfer time delays:

1. Provide the following field adjustable setpoints with the following ranges:
    a. Time delay to override momentary normal power source outages to delay transfer switch: 0 to 6 seconds.
    b. Transfer to backup power source time delay: 1 to 300 seconds.
    c. Time delay to re-transfer to normal power source (upon restoration): 0 to 30 minutes.

D. Manual transfer switch controls:
    1. Combination Display and Keypad: Provide manufacturer's standard four line, 20 character liquid crystal display (LCD) combination display and pushbutton keypad user interface module. The combination display and keypad module shall be an integral part of the ATS for viewing all available data and field adjustment of desired operational parameters. Mount the Combination Display and Keypad to the face of the ATS.

E. Accessories:
    1. Provide a detailed instruction plate for convenient operation.
    2. Auxiliary Contacts:
        a. All contacts shall be rated for 10 ampere at 120 volts A.C. Wire to terminal blocks.
        b. Provide contacts for the following:
            1) ATS in normal position.
            2) ATS in emergency (backup) position.
            3) Normal source voltage is present.
            4) Emergency (backup) source voltage is present.
            5) Additional contacts where required by the PLANS.
    3. Nameplates:
        a. Provide nameplates/legend plates for each pilot device and each component/device/equipment installed on the face and inside the enclosure of the ATS.
        b. Identification 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 be not be accepted.
            2) Color: White-Black-White.
            3) Lettering: Nameplate shall be legible at a distance of six feet from the nameplate. Lettering shall be engraved through the face layer to the melamine middle layer.
            4) Accessories: Provide holes for mechanical fastening
            5) Nameplates located on the face of the cabinet shall be secured with two Stainless Steel screws.

2.03 AUTOMATIC TRANSFER SWITCH (ATS) ENCLOSURE

A. The ATS assembly (controls, contactors, sensors, relays, etc.) shall be mounted in a NEMA-12 gasketed enclosure. The ATS controller combination display and keypad and switch operators shall be mounted on the face of the enclosure door. Each door shall have a continuous piano hinge with key-lockable stainless steel handle (3-point latching mechanism).

PART 3 EXECUTION

3.01 FACTORY INSPECTION AND TESTS

A. Standard factory tests shall be performed on the equipment specified in this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards. The manufacturer shall provide certified copies of factory test reports prior to shipment of the equipment to the project site. Format and quantities of the test report shall be in accordance to Section 01300 and Section 01730 of the Contract Specifications.

3.02 FIELD INSTALLATION (BY CONTRACTOR)

A. Mount the ATS as shown on the PLANS. Top of ATS shall be no higher than 6 foot 0 inches above the finished floor elevation. 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.

3.03 FIELD TEST AND CHECKS

A. The following minimum test and checks shall be made before energizing the ATS. These tests shall be performed by a Factory Trained Field Technician (non sales type):
   1. Thoroughly inspect ATS.
   2. Test for proper operation.
   3. Calibrate, set and test control timers, relays according to settings provided and required by this Specifications Section and as recommended by the manufacturer.
   4. Submit documentation of all tests outlined above. Include all test documentation data in operation and maintenance manuals.

3.04 EQUIPMENT PROTECTION AND RESTORATION (BY CONTRACTOR)

A. Clean and vacuum clean all interior of the equipment.

B. Touch-up and restore damaged surfaces to factory finish.

3.05 TRAINING

A. Provide training sessions for OWNER’s representatives for Two (2) normal workday and Four (4) working hours each day, at the job-site location. If training is conducted in less than the time required by these Specifications, the remaining time shall be utilized at the discretion of the OWNER.

B. The training session shall be conducted by the ATS manufacturer’s non-sales-type technical representative.

C. At minimum, the training session shall include:
   1. Operation and maintenance procedure for the equipment and all components installed within the ATS.

2. Factory contact persons phone numbers, persons names, ordering procedures and procedures to follow to obtain meaningful results from the factory.

3.06 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 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 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, 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/13, heavy duty, oil tight/corrosion resistant, hermetically sealed and rated for use in wet locations and in Class I Division 2 hazardous areas (as classified by NEC).
   2. Size: NEMA Style full size 30-millimeter (30mm),
   3. Contacts: 5 ampere minimum at 120 volts A.C. Hermetically sealed and stackable contact blocks. 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 800R, 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 shown on the PLANS:

D. Additional requirements for Emergency Stop/Trip Push-Button Stations:
1. Action Type: Push-Pull maintained
2. Operator Type: Mushroom head
3. Operator Color: Red, unless shown otherwise on the PLANS
4. Each button shall be provided with a hinged polycarbonate corrosion resistant locking cover. Cover shall be capable of closing without actuating the push button. Cover shall be C3 Controls Model LOAFC, or approved equal.
5. 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.

2.02 FIELD CONTROL STATION ENCLOSURE

A. Size: As required

B. Rating: NEMA-4X

C. Material: Type 316 Stainless Steel. Enclosures shall have a smooth, non-brushed finish.

D. Doors and door latches: Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches.

E. Manufacturer: Allen-Bradley, Hoffman, Rittal, Millbank, or approved equal.

2.03 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. 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 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 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, and other devices associated with the grounding system associated with the aforementioned.

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 -1.5 (NOT USED)

1.06 SUBMITTALS

A. Submit shop drawings on all grounding system product and in accordance with Section 01300 of the Specifications. Include material safety data sheet for ground enhancement material.

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 24 inch long by 24 inch wide by 1/4 inch thick high conductivity copper sheet plates as manufactured by Erico (Cadweld), or approved equal. Each ground plate shall have two bare copper 250 kCMIL wire pigtails exothermically welded to the plate by the plate manufacturer. Exception: ground plates connected to test wells are not required to have pigtails. Refer to the PLANS for additional requirements.

B. Concrete encased ground electrodes for all new buildings or structures having a concrete foundation shall be encased in the concrete foundation a minimum of 20 feet and tied to the foundation's steel reinforcing bar system. The concrete encased ground electrode shall be a minimum 3/4 inch diameter Type 316 stainless steel reinforcing bar per ASTM A955/A955M. The concrete encased ground electrode shall extend outside of the concrete foundation and turn up into a concrete encased electrode accessibility ground port enclosure as shown on the PLANS. Refer to the PLANS for additional requirements. The enclosure shall comply with the requirements of Section 16250 of the Specifications "Boxes and Cabinets".

C. Connections between ground electrode and grounding electrode conductors shall be made below grade using Cadweld, Burndy Thermoweld, or equal thermite reaction welding system. Exception: Connections between ground electrode 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.

D. Grounding electrode conductors/wire shall be green insulated stranded copper. Use bare copper for grounding grids only (as shown on the PLANS).

E. 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.

2.02 GROUND ENHANCEMENT MATERIAL

A. The Contractor shall encase the underground ground electrodes with the hereinafter specified Ground Enhancement Material.

B. Material: Low resistance non-corrosive carbon based backfill material, free of concrete and bentonite. Material shall not require periodic wetting or other Owner intervention in order to maintain its conductivity.

C. Application: Suitable for use as backfill material in rocky, sand, gravel, and other high resistance soil types to lower the ground resistance. Suitable for use in horizontal and vertical trench applications.

D. Manufacturer: Harger Model "Ultrafill", Erico "Ground Enhancement Material (GEM)", or approved equal.

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 and instrumentation equipment, including lights, receptacles, instruments, 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 plates; 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. After ground wire connections have been made to equipment, to structures, in test wells and encased grounding electrode accessibility ground port enclosures, etc., the Contractor shall apply “3M” 1601 Clear-Color Fast Drying Sealer and Insulator, or approved equal corrosion resistant and moisture repelling electrical coating/spray to all exposed wiring and all wire connections, inclusive of mechanical and exothermic weld connections. Coordinate application with the Owner.

N. Test grounding in accordance with Section 16800. Maximum resistance to ground shall not exceed 2.0-ohms. At no additional cost to the owner, install additional ground plates over the number required by the PLANS, as necessary to accomplish the 2.0-ohms or less resistance.

O. 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. Bonding jumper wire size as required by the National Electrical Code "N.E.C.", however, minimum wire size shall be #10 AWG.

P. Where Grounding System bare copper underground conductors pass through a transition from soil to concrete/mud slab concrete/flowable fill concrete/etc., the conductors shall be wrapped with 20 mil polyvinyl chloride based Pipe Tape using a 50 percent overlap. Pipe tape coverage shall be installed at the point of the transition and an additional 12 inches of distance beyond either side of the point of transition/contacted region. Pipe Tape shall be 3M Company No.51, or approved equal.

Q. Ground Enhancement Material Installation:
   1. All underground grounding electrodes shall be encased in an envelope of grounding enhancement material extending beyond the extents of the grounding electrode a minimum of 4 inches in all directions.
   2. Prior to installation, all ground enhancement material shall be mixed with water into a slurry in accordance with the ground enhancement material manufacturer's installation instructions. Salt water shall not be mixed with the grounding enhancement material.
   3. Refer to and comply with the installation details shown on the PLANS. Additionally, follow the ground enhancement manufacturer's installation instructions.

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 16600

DISCONNECT SWITCHES AND ENCLOSED CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Furnish and install disconnect switches and enclosed circuit breakers 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. For each individual Disconnect Switch and Enclosed Circuit Breaker include:
   1. Dimensioned/scaled fabrication drawings
   2. Ratings
   3. Wiring connection diagram
   4. 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. Include:
   1. Copies of the approved shop drawings
   2. On-site/field test data.

PART 2 PRODUCTS

2.01 DISCONNECT SWITCHES

A. Construction:
   1. U.L. Listed, Non-fused, Single Throw, Heavy Duty type. Complies with UL98 and NEMA KS-1.

2. Switchblades shall be fully visible in the "OFF" position when the door is open.
3. Dead-front construction with permanently attached arc suppressors.
4. Switches to have quick-make and quick-break operating mechanism and handles with provision for padlocking in all three positions, with at least four padlocks. The locking provisions shall be such that the padlock directly interferes with the operating handle and is fully visible.
5. Switches shall have a dual cover interlock to prevent unauthorized opening of the switch door in an "ON" position from either source, or closing of the switch mechanism with the door open.
6. 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 to be U.L. listed.
7. All current-carrying parts to be plated.

B. Ratings:
1. Voltage Rating: 600 Volts A.C.
2. Current Rating: Maximum continuous current capacity shown on the PLANS
3. Number of Phases: Three, unless shown otherwise on the PLANS
4. Minimum RMS symmetrical short circuit current rating: 10000 ampere at 208 volts A.C.

C. Enclosure:
1. NEMA-4X Type 316-Stainless Steel gasketed cabinets. Enclosures shall have a smooth, non-brushed finish.

D. Manufacturer:
1. All Disconnect Switches on the project shall be manufactured by a single Disconnect Switch manufacturer.
2. Square D Company Class 3110, Asea Brown Boveri, Eaton Cutler-Hammer Corporation, or approved equal.

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. Enclosures shall have a smooth, non-brushed finish.

C. Circuit Breaker Ratings:
   1. Voltage Ratings: 600 volts A.C.
   2. Current Rating: Maximum continuous current carrying capacity shown on the PLANS
   3. Number of Phases: Three, unless shown otherwise 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 auxiliary contacts where required by the PLANS. Contacts shall be rated for 5 ampere at 120 volts A.C. Coordinate contact requirements with the PLANS.
   9. 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, Asea Brown Boveri, Eaton Cutler-Hammer Corporation, or approved equal.

2.03 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-0-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 OWNER or the OWNER's designated 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 megohmeter.

B. Take each reading for at least one minute.

C. Include the following tests:

Equipment	Minimum Resistance
115 and 230 volt motors	5.0 Megohms
460 volt motors	7.0 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., Primary Treatment Complex 2, 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

A. 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.

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 Volts and Below)” paragraph 3.03 “Wire Tagging Methodology”.
   3. Calibrate, set and test the PICS equipment, components, cables, hardware, and software.
   4. For all PICS equipment and ancillaries, provide:
      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.
         4) Shaker table for vibration transmitters, etc.

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, software, and services for the installation of the DCS configuration system at 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 also shown on the PLANS, the proposed Distributed Control System at the Operations Building and at the Primary Treatment Complex 2 Building are networked with the OWNER's existing plant Top-End computer system by means of DCS equipment at the OWNER's existing Operations Building Control Panels and existing Substation No. 2 Building Control Panels, respectively. Refer to the PLANS. Effort is required of the ICS to establish functional and complete communication network links between the proposed equipment of this project and the Owner's existing DCS equipment in order to achieve proper and complete system operation. This effort shall include, but not be limited to:
    1. Furnish and install proposed communication equipment and associated cabling in the OWNER's existing Operations Building and Substation No. 2 Building Distributed Control Panels. Refer to the PLANS.
    2. 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
    3. System startup testing, diagnosing, and resolving communication system issues, etc.

4. Modifications to the single mode fiber patch panel patch cord connections at the existing single mode fiber patch panels in other existing process areas within the Owner's treatment plant to achieve a functional and operating data communication network to the Owner's Top-End system. Refer to the PLANS for quantity of process areas and overall plant control system architecture. Furnish and install quantity of single mode patch cords within the existing plant process areas as required as well as reconfigure existing patch cords within process areas as required to establish the functional data communication links.

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 treatment plant process system. Therefore, required interruptions to the OWNER's existing distributed control system shall be minimized and coordinated with the OWNER. Should an outage to a facility be required, the Contractor shall request such an outage in writing no less than ninety-six (96) hours in advance. Contractor's written request shall identify the desired date, time, duration, and purpose of the requested day unless he/she obtains a written approval from the owner authorizing the outage. The OWNER reserves the right to modify or reject any request such an outage. Modification or rejection of the contractors request be the OWNER shall not be considered reason for delays in the construction schedule. Unless otherwise noted, the duration of the outage shall be limited to four (4) hours or less. The OWNER reserves the right to limit the duration of the outage to less than 4 hours. Modification of the outage duration by the OWNER shall not be considered reason for delays in the construction schedule.

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 divisions 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:
   1. 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.
   2. All system layout drawings, cross sectional view drawings, wiring diagram drawings, Connection detail drawings, physical layout and detail drawings, etc. shall be developed electronically using “AUTOCAD software”.

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 for multiple equipment shall not be accepted.
4. Contractor may submit wire tag samples for all types of interconnect and field wiring from the proposed/existing cabinets/panels with associated point-to-point wiring diagrams in a separate submittal for approval prior to submitting the complete wire tag schedule for review. After approval of the sample wire tags, a wire tag table showing all provided wire tags shall be submitted for review with the associated point-to-point wiring diagrams. Refer to Specification 17100 Subsection 1.03.C.5 for additional wire tag table requirements. Refer to Specification 16200 Subsection 3.03 for wiring tagging methodology.
5. Wire Tags: Contractor shall also submit for approval a complete schedule of all wire tag numbers sorted by area and equipment/instrument/field device. It is anticipated that all wire numbers cannot be accommodated on the loop diagrams, ladder diagrams, control schematics, etc. format shown on the PLANS. As a minimum, to facilitate the depiction of the wire numbers on the loop diagrams, ladder diagrams, control schematics, etc., the Contractor shall generate and include uniquely identified alpha-numeric wire codes on the loop diagrams, ladder diagrams, control schematics, etc. The wire codes shall cross-reference tables of wire numbers shown on additional drawings that shall be generated by the Contractor. At minimum, the Contractor shall generate the wire codes and the cross-reference tables which depict the wire numbers associated with each wire code and shall group the cross-reference tables by specific equipment (Sludge Pump No. 1, Sludge Pump No. 2, Sludge Pump No. 3, etc.). As a minimum, the Contractor shall generate drawings to depict the wire code and wire tag cross-reference tables and these drawings shall also be grouped by specific equipment (Sludge Pump No. 1, Sludge Pump No. 2, Sludge Pump No. 3, etc.). Additional requirements concerning the cross-reference table headings, table organization, wire code generation, formatting, etc., shall be provided by the Owner during the Pre-Submittal Conference specified hereinafter (*refer to subsection 1.03G in this Section of the Specifications*) and the Contractor shall incorporate these requirements at

no additional cost to the Owner. Contractor shall submit wire tag samples for all types of interconnect and field wiring from the proposed/existing cabinets/panels with associated point-to-point wiring diagrams in a separate submittal for approval prior to submitting the complete wire tag schedule for review.

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).
      c. Submittals shall include hard copies (of the quantity and format required by the Contract Documents) and electronic Version in “AUTOCAD”; This applies to all drawings requested in this Section of the Specifications and any other manufacturer’s product standard drawings required for submittal.
   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. International Society of Automation (ISA) Standards.
   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.

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 Procurement 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 5 - EXECUTION:
      a. Operational Readiness Test "ORT"
      b. Performance Acceptance Tests "PAT".
   3. Test Format: Cause and effect
      a. Person conducting test initiates 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. 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) Model 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, 25, 50, 75, and 100 percent of span, rising and falling
    b) Discrete Devices: Actual trip points and rest points
    c) Controllers: Mode settings (P&ID)
    d) PLC I/O Modules: Actual inputs or outputs of 0, 25, 50, 75, 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 one hundred and five (105) 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.

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.

END OF SECTION

SECTION 17200

INSTRUMENTATION AND CONTROL CABINETS AND ASSOCIATED EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Furnish, install, and put into satisfactory service the Operations Building 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 Primary Treatment Complex No. 1 Building Main Instrumentation/Control Panels, Local Control Panels, Distributed Control System Panels, as specified herein and as shown on the PLANS.

C. Furnish, install, and put into satisfactory service the Primary Treatment Complex No. 2 Building Main Instrumentation/Control Panels, Local Control Panels, Distributed Control System Panels, as specified herein and as shown on the PLANS.

D. Furnish, install, and put into satisfactory service the modifications to the Owner's existing Electrical Substation No. 2 Building Main Instrumentation/Control Panels and/or Distributed Control System Panels as specified herein and as shown on the Drawings.

E. 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.

C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

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. Two (2) complete Instrument Loop Current Isolators (I/I converters) for each type specified.
   7. Two (2) complete Programmable Pump Controllers, complete with all accessories.
   8. 25 percent spare push-buttons, selector switches, indication light assemblies for each type used (minimum of 2 per type).
   9. 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

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 (e.g. PLCs, etc.) will 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 where possible. Each Single Bay section shall have one door, and each Double-Bay section shall have two doors, unless specifically shown otherwise

on the PLANS. Provide sections with rear doors where specifically shown 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 factory 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. Exception: fans and louvers are not required for rear doors.
    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/Rack Mounted Cabinets/Panels

1. Each enclosure shall be 316 stainless steel NEMA 4X. Enclosure shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches. Provide door latch handle. Enclosures shall have a smooth, non-brushed finish. Furnish and install pad locking means for the door/handle.
2. Each enclosure door assembly shall be furnished with manufacturer's door stop kit that will hold the door open in any position between 0-130 degrees. Each door shall be electrically bonded to the frame of the associated enclosure with #8 AWG 600 volts insulated green ground wire. Utilize manufacturer's grounding device assembly. The inside of each door shall be equipped with the manufacturer's data-pocket for storing drawings and manuals.
3. Each enclosure shall be furnished with a full and solid backpanel (one piece full subpanel). The backpanel shall extend the full height and width of the cabinet/panel. The backpanel shall be factory painted white.
4. Cabinet/Panel manufacturer's additional hardware and component accessories shall also be provided that will result in a neat, safe, aesthetically pleasing installation. Adherence to this requirement is necessary in order to accomplish a good craftsmanship-like system installation to the satisfaction of the Owner and Engineer.
5. Each enclosure shall be as manufactured by "Hoffman" model Concept series industrial enclosures complete with specified accessories, or approved equal by "Rittal".
6. The minimum anticipated panel size for each wall/rack mounted cabinet/panel is shown on the PLANS. The Contractor shall size each cabinet/panel per the requirements of the NEC. Contractor to determine exact as-built size required for the cabinet/panel to meet the contract documents (drawings and specifications) without any additional cost to the Owner (should the final size be larger than that which was anticipated by the PLANS). Additionally, the Contractor is to carefully review the electrical/control floor plan drawing and make any adjustments/equipment rearrangements necessary to meet National Electrical Code requirements and any other safety codes adopted by the City of Austin should the cabinet/panel size be any greater/larger than the minimum size required by the PLANS. Conduit/wiring, etc. adjustment caused by any equipment rearrangement, etc. shall also be provided at no additional cost to the Owner.

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. The pigmentation of the wire insulation shall conform to the color table listed below:

Wiring Function	Wire Jacket Color
Wiring for 120 volts A.C. control/status signal wiring. This does not apply to control/status signal wiring that are scheduled for interface with Programmable Logic Controller (PLC) and Alarm wiring	Red
Wiring for 120 volts A.C. control to relay coils (L1 & L2 terminals or H&N terminals) that are not generated from a PLC Discrete Output point (DO)	Gray
Wiring for 120 volts A.C. power to instrumentation and control devices that are not generated from a PLC Discrete Output point (DO)	Gray
Alarm wiring	Yellow
Wiring for 24 volts D.C. power supply wiring	Blue = Positive Brown = Negative
Wiring for 120 volts A.C. light fixtures, convenience receptacles and exhaust fans	Red = Line (Phase A) Black = Line (Phase B) Blue = Line (Phase C) White = Neutral
Wiring to Discrete Input PLC modules	Violet
Wiring to Discrete Output PLC modules	Pink
Ground wires	Green

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. Lighting Fixture:
1. Furnish and install where required by the PLANS. Additional light fixture features are as follows:
a. Type: LED
b. Voltage: 120 volts A.C
c. Length: 14 inches
d. Lumens per fixture: 400 lumens
e. Although it may not be shown on the PLANS, furnish and install two light fixtures per vertical section of control panel enclosure
f. Motion sensors shall not be accepted.
g. Furnish and install manufacturer's extension cable to connect to fixture.
h. Furnish and install door switch wired to switch the light based upon door position

D. 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.

E. 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-HA33A1-3-4, complete with 700-HN205 socket, 700-AV3R surge suppressor, and 700-HN157 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: Provide universal mounting strip/plate for backpanel 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. (nominal voltage)
   c. Position Indication: Integral LED pilot light
   d. Manual Operator: Integral to relay
   e. Contact Rating: 10 ampere at 120 volts A.C.
   f. Number and Configuration of Contacts: four (4) Form-C Contacts (4PDT)
   g. Mounting: DIN rail mountable socket
   h. Accessories: LED indicator light, Push-to-Test button, socket and retaining clip
   i. Miscellaneous: Used only where specifically noted on the DRAWINGS.
   j. Manufacturer: "Allen-Bradley", catalog 700-HF34Z24-3-4, complete with relay socket base catalog number 700-HN139 and relay retaining clip 700-HN140, or approved equal.

F. 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.

G. 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.

H. 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

I. Programmable Pump Controller
1. General: Field programmable pump controller with integral front display and programming buttons.
2. Display: Six (6) LED, fourteen (14) segment alphanumeric characters
3. Input signals: 0-20mA, 4-20mA, 0-5V, 0-10V, or -10-10V selected from keypad
4. Output signal: 4-20mA analog retransmission
5. Alarm points:
    a. Four (4) independently set, trip and reset points
    b. Latching or non-latching, selected from keypad
    c. Contacts: SPDT (form C) relays rated 7.5 amps at 240 VAC / 24 VDC
    d. Audible alarm configurable for each channel
    e. Front panel flashing display
6. Performance:
    a. Accurracy: ±0.01% of input range
    b. A/D resolution: 20 bits
    c. Display resolution: +9999 to -1999 in count steps
    d. Common mode rejection: Greater than 120 dB at 50/60 Hz
    e. Normal mode rejection: Greater than 64 dB at 50/60 Hz
    f. Operating temperature: 32° to 158° Fahrenheit
7. Power: 120 VAC
8. Housing:
    a. Aluminum body
    b. Splash proof front panel
9. Mounting: Panel mountable on the face of the instrumentation and control cabinet door
10. Menu Access Security: Six (6) digit, user selectable, password to enter configuration menu
11. Manufacturer: Devar, Inc. Model 3020 with specified options, or approved equal.

J. 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 PLANS
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.

K. 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

L. Terminal Blocks:
1. Type: Single Layer
2. Rating: 600 volts A.C./D.C., 55 ampere
3. Wire Range: No. 22 through No. 8 AWG
4. Material: Nylon or polypropylene
5. Quantity per Foot: 37

6. Terminal Block Colors: Provide terminal blocks with the colors as follows:

Terminal Block Function	Terminal Block Color
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

7. Manufacturer: Allen-Bradley Bulletin 1492-HM3, Phoenix Contact, or approved equal.

8. Accessories:
   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.

M. Flexible spiral wrapping: Size as required. Provide as manufactured by Electrovert Spiraband, or approved equal.

N. Plastic Wireway: Size as required. Also refer to the PLANS. Provide white color unless specified otherwise. Provide as manufactured by Panduit, or approved equal.

O. 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.

2.04 INSTRUMENT CONTROL PANELS/CABINETS UPS:

A. Where required by the PLANS, furnish and install the quantity of Uninterruptible Power Supply (UPS) units in each of the instrument/control/communication cabinets as shown on the PLANS. Each UPS shall be as follows:
   1. The UPS shall have the apparent power rating as shown on the PLANS at minimum.
   2. Each UPS shall operate from 120 VAC input power and shall provide 120 VAC output power. The UPS shall have a capacity to deliver the continuous full load AC output current shown on the PLANS at 120 VAC for fifteen (15) consecutive minutes at minimum, after the input power is removed. The

output wave form shall be 60Hz sinusoidal with 5% maximum harmonic distortion. The UPS shall be filtered with 0.3% IEEE surge let-through and zero clamping response time, complying with UL 1449 requirements. The output shall have over current protection with latched shutdown.

3. The UPS shall consist of a field configurable bypass mode for automatic or manual bypass to the AC input source
4. 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. Upon inverter module failure, the UPS shall automatically direct connect the connected load to the input power source and bypass the inverter module.
5. 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.
6. The UPS shall have the following front panel indications (LED type) and alphanumeric display:
    a. UPS On Status
    b. Fault
    c. On Battery
    d. Bypass
    e. Battery Replacement Needed
7. The UPS shall have the following audible alarms:
    a. UPS failure
    b. Battery failure
    c. Power loss to the UPS
8. The UPS shall have the following front panel mounted push buttons:
    a. Energizing UPS
    b. De-energizing UPS
    c. Manual UPS Self test initiation
9. The batteries shall be maintenance-free, fumeless, sealed, leak proof batteries that are accessible for replacement by the OWNER. The batteries shall be rated for use in Computer Rooms (by NFPA and all other Safety Codes). Batteries shall have maximum of five (5) hours to charge to 95 percent capacity. 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.
10. 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.
11. The UPS and the battery backup units shall be installed in a NEMA-12 enclosures
12. The UPS shall be able to operate from 0 to 40 degrees C.
13. 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, and a dry contact indicating requirement for Battery Replacement. 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.

c. Provide all 19 inch rack mounting brackets, miscellanous 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.

14. The UPS shall have a two (2) year manufacturer's warranty at minimum after the final completion of the project

15. The UPS shall be as manufactured by Eaton Model 9PX Series UPS with external maintenance bypass switch Eaton HotSwap MBP Model EHBPL****R-PDU1U (where **** is based on UPS rating shown on the PLANS), and Relay Interface Card Eaton Model No. Relay-MS , or approved equal.

2.05 PROGRAMMABLE LOGIC CONTROLLERS "PLCS", AND ASSOCIATED EQUIPMENT

A. Refer to Specifications Section 17600, "Distributed Control System DCS" of the Specifications.

2.06 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 be 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.

2.07 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 repellant 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 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.
3. 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.
4. 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).
5. 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.
6. Tag each terminal block. All tags must be typed and neatly attached to the marking surface.
7. Tag each terminal strip/string of terminal blocks with nameplates as previously specified.
8. Terminal blocks shall have the colors previously specified according to the function of the terminal block.
9. Utilize manufacturer’s standard terminal block insulated side jumpers for making connections between adjacent terminal blocks.
10. 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.
11. 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.
12. Wire entering the cabinets shall enter through the floor, the side and/or the top of the cabinets via conduits with bushings or hubs.
13. 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.

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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/elements as shown on the PLANS:
   1. Intelligent Pressure Measuring Indicating Transmitters
   2. Intelligent Temperature Measuring Indicating Transmitters
   3. Sludge Blanket Level Element and Indicating Transmitters
   4. Electrical Conductivity Actuated Level Switches
   5. Radar Level Element and Indicating Transmitters
   6. Ultrasonic Clamp-On Flow Element and Indicating Transmitters
   7. Digital Loop Powered Indicators
   8. Tubing, Hand Valves and Fittings
   9. Wire Mesh Grips
   10. Hoods (Sun-Shields)
   11. Stand-Pipes
   12. Supports Systems Constructed of Pipes and Pipe Fittings

B. Additionally, coordinate, install, assist in calibration, test, and place into satisfactory service the following field mounted devices furnished as described in Sections 17502 and 17511 of the Specifications:
   1. Air Bubbler Assembly
   2. Suspended Solids Analyzers
   3. Magnetic Flow Meters

C. The subsequent document entitled “Appendix A – 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, the CONTRACTOR shall note these items on the data submittals and request input from the Process Mechanical ENGINEER for clarification during submittal review.

D. Instrument Type Code:
   1. An Instrument Type Code identifies each instrument and consists of alphabetical character(s) 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.

C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

A. Submit the following in accordance with the requirements of Sections 01300 and 01730 of the Specifications and in accordance to Section 17100 of the Specifications:
   1. Shop drawings and product data.
   2. Wiring schematics for all equipment.
   3. Submit a physical mock-up of a product/item where a mock-up is noted/required for the product/item in this specification section.
   4. Certifications of training associated with proper installation the fiberglass reinforced vinyl ester support channel system.
   5. 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.
   6. Operation and maintenance manuals.
      a. Include all completed and certified test reports in manuals.
         1) Refer to specifications herein for transmitter ambient and process fluid temperature ranges to be used for basis of accuracy analysis.
   7. 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 trouble-shooting, 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.
      d. 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 Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. 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 where such products are specified for this Work.

E. All chemicals and products/elements that are in contact with potable/drinking water shall conform to ANSI/NSF Standard 60 for Drinking Water Treatment Chemicals and ANSI/NSF Standard 61 for Drinking Water System Components.

F. 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 F713 Ultrasonic Flow Measuring Indicator/Transmitter, furnished complete with accessories specified.
   2. One set of complete Type I107 Digital Loop Powered Indicator, furnished complete with accessories specified.
   3. One set of complete Type L205 Sludge Blanket Level Measuring Indicator/Transmitter, furnished complete with accessories specified.
   4. One set of complete Type L301 Electrical Conductivity Actuated Level Switch, furnished complete with accessories specified.
   5. One set of complete Type L718 Radar Level Measuring Indicator/Transmitter, furnished complete with accessories specified.
   6. One set of complete Type P104 Intelligent Pressure Measuring Indicator/Transmitter, furnished complete with accessories specified.

7. One set of complete Type P125 Intelligent Pressure Measuring Indicator/Transmitter, furnished complete with accessories specified.
8. One set of complete Type P131 Intelligent Pressure Measuring Indicator/Transmitter, furnished complete with accessories specified.
9. One set of complete Type T103 Intelligent Temperature Measuring Indicator/transmitter, furnished complete with accessories specified.
10. One set of complete Type T118 Intelligent Temperature Measuring Indicator/transmitter, furnished complete with accessories specified.
11. Five sets of Instrument Tubing Hand Valves.
12. 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:
      a. Configuration of spare instrument shall be as directed by Engineer during construction.
      b. Request input from Engineer during submittal process as to which configuration is desired for the spare instrument.

D. Furnish the following tools:
   1. Two (2) handheld HART communicator configurators, each complete with 120 Vac charging station, test lead kit, rechargeable battery, USB cable, carrying case, hand strap, SD card, and software as manufactured by Yokogawa Model YHC5150X FieldMate Handheld Communicator, no equal.

1.06 MOCK-UPS

A. Where a mock-up is noted for a product/item specified in this section, provide each mock-up per the following requirements:
   1. The Contractor shall construct/fabricate the mock-up and submit it for review only after shop drawings for the product/item associated with the mock-up have been developed and submitted by the Contractor for review and the review process of the shop drawings by the OWNER and ENGINEER is complete.
   2. Hand the fabricated mock-up to the OWNER. Package the mock-in a cardboard box and/or otherwise protected from the elements during storage and handling.
   3. Each mock-up shall be considered a sample with regard to the submittal procedures for this Work.
   4. The mock-up protective packaging shall have a label that shall include, at a minimum, the following information typed on the label:
      a. Project title,
      b. Name of the submitting Contractor and Sub-Contractor, as applicable,
      c. Name of the intended recipient,
      d. Physical address of the intended recipient,
      e. Submittal number, and

f. Submittal specification section.

5. Each mock-up shall be handed to the OWNER with a transfer of materials memorandum hard-copy document. The Contractor shall make a copy of the signed version of the transfer of materials memorandum and include it as part of the mock-up submittal documents. The transfer of materials memorandum shall include, at a minimum, the following information:
   a. Printed name and signature of the Contractor representative that handed the mock-up to the OWNER,
   b. Printed name and signature of the OWNER representative acknowledging recipient of the mock-up,
   c. A description of the mock-up submitted,
   d. The date and time of day the mock-up was handed to the OWNER, and
   e. The physical address of the location where the mock-up was handed to the OWNER.
6. For each physical mock-up submittal, provide mock-up submittal documents. The mock-up submittal documents shall include, at a minimum, the following:
   a. Standard submittal cover pages per the submittal procedures for this Work.
   b. A copy of the prior reviewed shop drawing of the mock-up.
   c. Pictures of the submitted physical mock-up.
      1) Six pictures, each enlarged on a letter sized page, one for each of the six (6) sides of the mock-up (top, bottom, right, left, back, and front sides).
      2) Additional pictures, with a measuring tape (units of inches showing) placed on the applicable features of the mock-up to illustrate the thickness/gauge and dimensions of materials used to fabricate the mock-up, where such material thicknesses and dimensions are specified for the product/item.
      3) Provide additional pictures as required to communicate details of the mock-up.
   d. A copy of the physical mock-up submittal transfer of materials memorandum.
7. All mock-ups required for this Work shall be in addition to the quantity of products/items to be installed as required per the specifications, the Instrument List and/or as shown on the DRAWINGS.
   a. All mock-ups shall be in addition to any spare parts noted in this section.
   b. All mock-ups shall remain the property of the OWNER and may not be used/installed by the Contractor as part of the final Work unless specifically authorized in writing by the OWNER or the ENGINEER.
8. For a product for which a mock-up is required, if there is more than one installation of the product/item, and the individual installations have different sizes and/or capacities, unless a specific size/capacity is noted to serve as the basis for the mock-up, the Contractor shall provide a mock-up of the installation having the largest size/capacity required for this Work.
   a. The Contractor shall note on the product shop drawings submitted for review prior to the mock-up submittal which size/capacity of the product shall serve as the basis for the mock-up.

1.07 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 TRANSMITTERS

A. P100 Series General Requirements:
   1. The Pressure Indicator/Transmitter shall have the following features:
      a. Signal: Two-wire 4-20 mAdc (loop powered) and having an integral digital signal based on the HART communication protocol.
         1) Alarm: Configure the unit fault/alarm at 21.75 mAdc output signal.
      b. Measurement Stability Period: 15 years
      c. Unit Warranty: 15 years
      d. Ambient Temperature Range: –40 degrees Fahrenheit to +175 degrees Fahrenheit
      e. DC Loop Supply Voltage Range: 12 to 42 VDC.
      f. Signal Output Load Range: 200 to 1,450 ohms.
      g. 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. Select gauge or absolute measurement as applicable.
      h. 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.
      i. Power: Loop powered (4-20mA at 24 VDC) with 1/2" NPT conduit connection.
      j. Wetted Parts Material: Type 316L Stainless Steel. Elements in contact with process fluid shall have NSF drinking water approval.
      k. 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 flange (not coplanar) configuration.
      l. Sensor Fill Fluid: Silicone oil.
      m. Process Connection: 1/2 inch NPT.
      n. Transmitter Housing: Epoxy coated aluminum, explosion proof NEMA-4X.
      o. Hardware: Type 316 Stainless Steel.
      p. 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. Mounting: Manufacturer's Type 316 Stainless Steel mounting bracket suitable for mounting transmitter assembly on 2-inch pipe stand, support channel, wall/panel or other surface as shown on PLANS. Provide stainless steel flange to mount vertical pipe stand to floor. Refer to the PLANS for additional requirements.
4. Instrument Tubing: Provide instrument tubing to process line connections at valve block process ports. Refer to tubing and fittings requirements in this Specification Section. Refer to PLANS for additional requirements.
5. The Intelligent Pressure Measuring Indicators/Transmitters shall be as manufactured by Rosemount Series 3051S Ultra Class or greater accuracy (Intelligent 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; Anderson Greenwood Model M4TP-VIS4 with Model AMS Type 316 Stainless Steel mounting bracket or Engineer approved equal. Refer to PLANS for additional valving on process piping pressure tap.
   3. Mounting of Manifold and Transmitter: Mount manifold directly with specified manifold mounting bracket. Manifold shall be installed between Transmitter bottom works and bracket. Transmitter shall be supported by manifold.
   4. 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. P125: Intelligent Pressure Measuring Indicating Transmitter with Integral Threaded Diaphragm Seal:
   1. General Requirements for P100 Series Intelligent Pressure Measuring Indicating Transmitters apply to this type of instrument.
      a. Exception: The Type P125 Intelligent Pressure Measuring Indicator/Transmitter shall not have a bottom works (traditional or coplanar). Each Type P125 Intelligent Pressure Measuring Indicator/Transmitter shall be as manufactured by Rosemount Series 3051S Ultra Class or greater accuracy (Intelligent Transmitters) with an In-line Pressure Transmitter configuration and specified accessories, or Engineer approved equal.
   2. Pressure Seal Requirements:
      a. Temperature Error: Less than 0.1% instrument error based on the listed 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.

3. Diaphragm Pressure Seal: Provide factory furnished, factory assembled pressure transmitter assembly including 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: Integral 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: Factory installed diaphragm seal onto the transmitter. Orient and position the diaphragm seal relative to the required side of the transmitter bottom works to allow the installation of the transmitter and to provide a fully accessible and functional system. Refer to PLANS for additional requirements.
   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

D. P131: 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. Pressure Seal Requirements:
      a. Temperature Error: Less than 0.1% instrument error based on the listed 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.
   3. 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 with Protective Coat
o. Capillary Outer Diameter: 0.294 inches, including flexible armor and protective coat.
p. 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)

l. 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.

m. 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 handled programmer and/or Portable Computer) shall not be required in order to configure, program, and calibrate the Indicators/Transmitters.

n. Mounting Hardware: Manufacturer’s Type 316 Stainless Steel mounting bracket suitable for mounting transmitter on 2-inch pipe stand, support channel, wall/panel or other surface as shown on PLANS. Refer to the PLANS for additional requirements.

3. The Temperature Sensor Element for each Indicator/Transmitter shall have the following features:
a. General: 4-wire, single element, 100Ω (Ohms) Resistance Thermometer Detector (RTD), Platinum, in accordance with IEC 60751 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. Each Intelligent Temperature Measuring Indicator/Transmitter along with the associated Temperature Sensing Element and System shall be as manufactured by Rosemount Series 644 Intelligent Temperature Transmitters with Series 214C Sensor Element, Series 114C 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. Transmitter with required 316 Stainless Steel connector fittings.

C. T118: Intelligent Temperature Measuring Indicators/Transmitters with Remote Mounted Temperature Element for Process 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: Remote from sensor.
   3. The Sensor Element Thermowell shall have the following features:
      a. Thermowell Insertion Length:
         1) Pipe Installation: Equal to the radius (based on nominal diameter) of the process pipe in which thermowell is inserted. Maximum length of 36 inches.
         2) Duct Installation: Equal to one-half the depth of the duct (the depth of duct parallel to the direction of insertion of the thermowell) of the process duct in which thermowell is inserted. Maximum length of 36 inches.
      b. Sensor Assembly Connection: 1/2 inch NPT threaded to sensor.
      c. Process Connection:
         1) Thermowell Length 12 Inches or Less: 3/4 inch NPT threaded to process pipe.
         2) Thermowell Greater Than 12 Inches: 1-1/4 inch NPT threaded to process pipe.
      d. Terminal Enclosure:
         1) NEMA-4X, polyurethane coated, die-cast aluminum.
         2) Terminal blocks for termination of sensor and field wiring.
         3) Extended height enclosure with field removable and gasketed cover.
         4) Electrical Connection: 3/4 inch NPT threaded.

2.03 SLUDGE BLANKET LEVEL ELEMENT AND INDICATING TRANSMITTERS

A. L205: Requirements
   1. The sludge blanket level instrument shall consist of a self-cleaning stainless steel immersion probe element and a transmitter.
   2. Probe Components:
      a. Body: Stainless Steel
      b. Wiper: Silicon

c. Face: Polyoxymethylene
d. Cables and Power Cord: provide factory furnished length to suit installed conditions.

3. Factory Furnished Accessories:
   a. Mounting Kit
      1) Stainless Steel mounting kit to mount the level indicating transmitter to a wall, 2-inch post and/or railing as required for the installation and as shown on the PLANS.
      2) Stainless Steel mounting kit for the probe shall include Stainless Steel pipe supports, a Stainless Steel 3.3-foot extension pipe, a Stainless Steel hinged pivot, and a Stainless Steel rotating pipe section having a probe protection plate suited to temporarily lift/tilt the probe as required for rotating skimmer applications and as shown on the PLANS.
   b. Replacement Wiper Blades
      1) Package of five (5) replacement wiper blades.
4. The probe shall be equipped with the following:
   a. Magnetic coupled wiper that cleans the probe.
   b. Position sensor that also compensates for angle when the probe is not mounted exactly vertically.
   c. Automatic temperature compensator.
   d. Visual performance LED indicator light for assurance of proper performance.
5. Measurement Procedures:
   a. The probe shall define the sludge blanket based on user-selected sludge concentration or "blanket threshold".
   b. The method of measuring sludge level shall be by ultrasonic pulse directed toward the sludge blanket in the tank
   c. Height and depth measurements shall be based on the time it takes for the ultrasonic echo to return to the probe.
   d. The probe shall be factory calibrated and shall allow users to enter a correction factor.
   e. The probe shall automatically detect deterioration of disrupted sedimentation. It shall sense the ultrasonic echo return with the information of the separation layer independent of density.
6. Performance Requirements:
   a. Measurement range: 0.6 to 40 feet
   b. Measurement interval: 10 to 600 seconds (field adjustable)
   c. Accuracy: ±0.33 feet
   d. Resolution: 0.09 feet
7. Operating Temperature: 35 to 122 degrees Fahrenheit
8. Maintenance Service:
   a. Monthly: Visual inspection, if necessary, clean
   b. Annually: Change wiper blade, or after 20,000 wiping cycles
9. Installation and Programming:
   a. The probe must be installed with the ultrasonic head submerged at least 8 inches.
   b. Program the transmitter and probe to provide a fully functional system.
   c. Coordinate instrument programming parameters including sludge blanket densities and other fluid properties with field conditions and Process ENGINEER.

10. Indicating Transmitter:
    a. Mounting: Remote from sensor.
    b. Output Signal: 4-20 mA
    c. Power: 120 VAC
    d. Local Indicator: LCD outdoor UV rated indicator screen
    e. Interface: Buttons on face of transmitter for instrument configuration and menu navigation
11. Each Sludge Blanket Level Element shall be as manufactured by Hach Sonatax sc Sludge Blanket Level Probe with a Hach sc200 transmitter with a digital display screen or Engineer approved equal or Engineer approved equal by Analytical Technology, Inc. (ATI) Entech Design division, the Eco Smart series.

2.04 ELECTRICAL CONDUCTIVITY ACTUATED LEVEL SWITCHES

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.Each 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. L301: Electrical Conductivity Actuated Single 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 single level unit, with one switch and two total rods.

2.05 RADAR LEVEL ELEMENT AND INDICATING TRANSMITTERS

A. L800 Series General Requirements:
   1. The radar level element and indicating transmitter instrument shall consist of a horn antenna level transmitter and a remote-mounted level indicator.
   2. The Level Transmitter shall have the following features:
      a. General: Continuous level measurement for liquids.
      b. Frequency: 80 GHz High Frequency W-Band.
      c. Measuring Range: Up to 98.43 feet.
      d. Allowable Deviation of Measured Value: +/- 2 mm (+/- 0.08 inches) maximum.
      e. Adapter Flange: 4-inch 150-pound FF, ASME/PP-GF30 D FKM (SHS FPM 70C3 GLT) and PP/-40 to +176 degrees-Fahrenheit (-40 to + 80 degrees-Celsius).
      f. Ambient, Storage and Transport Temperature: -40 to 176-degrees-Fahrenheit.
      g. Materials:
         1) Wetted Parts: Type 316L Stainless Steel.
         2) Process Seal: FKM
      h. Housing:
         1) Material: Aluminum, IP66/IP68 (0.2 bar).
         2) Area Classification Ratings (minimum): FM CL I, II, III DIV1 ABCDEFG.
      i. Output Signal: 4 to 20 mA/HART.
      j. Power:
         1) Loop powered, 2-wire.
         2) Operating Voltage: 12 to 35 V DC.
      k. Cable Entry: 1/2-inch NPT.
      l. Mounting Hardware:
         1) Factory furnished Type 316 Stainless Steel mounting hardware.
         2) Provide all required hardware, bolts, washers, and nuts for a proper and secure installation. All hardware, bolts, washers, and nuts shall be Type 316 Stainless Steel.
         3) Refer to PLANS for additional requirements.
   3. The remote-mounted Level Indicator shall have the following features:
      a. Materials:
         1) Housing: Die-Cast Aluminum.
         2) Inspection window in housing lid for display and adjustment module shall be Polycarbonate (UL-746-C listed).
         3) Ground Terminal: Type 316Ti/316L Stainless Steel.
      b. Minimum Cable Length:
         1) Provide manufacturer furnished cable between the level transmitter and the remote-mounted level indicator.
         2) Allow for up to 164 feet of 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.
      c. Indicating and Adjustment Module:
         1) Indication: LC display in dot matrix.
         2) Adjustment Elements: 4 keys.
      d. Cable Gland: M20 x 1.5.

e. Cable Entry: 1/2-inch NPT.
f. Wire cross Section (Spring-Loaded Terminals): Massive wire, stranded wire AWG 24 to 14.
g. Ambient Conditions:
    1) Storage and Transport Temperature: -40 to +176 degrees-Fahrenheit.
    2) Ambient Temperature: -4 to +158 degrees-Fahrenheit.
h. Housing:
    1) Enclosure Rating (minimum): NEMA Type 6P.
    2) Area Classification Ratings (minimum): CSA (NI) CL I, DIV2, GP ABCD; (DIP) CL II, III, DIV I, GP EFG.
    3) Mounting Style: DIN Rail.
i. Mounting Hardware:
    1) Provide a 1/4-inch thick Type 316 Stainless Steel plate to serve as a backplane onto which to mount the instrument. The plate face dimensions shall be 7-inch x 7-inch minimum and as required to mount the instrument onto the plate. Drill the necessary holes into the plate as required for all mounting bolts.
    2) Fasten the instrument onto the 1/4-inch thick Type 316 Stainless Steel plate with four (4) sets of bolts, washers, and nuts and as required per the level indicator mounting holes.
    3) Fasten the Type 316 Stainless Steel plate onto channel supports.
    4) Provide all required hardware, bolts, washers, and nuts for a proper and secure installation. All hardware, bolts, washers, and nuts shall be Type 316 Stainless Steel.
    5) Refer to the PLANS for additional requirements.

4. Field Configuration Capability:
    a. The level instrument shall have keys/buttons on the face of the instrument as required for the basic start-up and configuration of the unit.
    b. Provide additional instrument manufacturer software and associated instrument manufacturer hardware and/or computer interface cable for field programming of instrument from a computer or other digital device for instrument start-up and measurement optimization.
5. The radar level transmitter and remote-mounted level indicator shall be as manufactured by VEGA Grieshaber KG and include the Series VEGAPULS 64 level transmitter and Series VEGADIS 81 remote-mounted level indicator complete with specified accessories or Engineer approved equal.

B. L818: Radar Level Element and Indicating Transmitter – Non-Flanged Transducer
1. General Requirements for L800 Series Radar Level Element and Indicating Transmitters apply to this type of instrument.
2. Radar Antenna:
    a. Type: Horn.
    b. Diameter: 4.02-inches (maximum).

C. L819: Radar Level Element and Indicating Transmitter – With Flanged Transducer
1. General Requirements for L800 Series Radar Level Element and Indicating Transmitters apply to this type of instrument.
2. Radar Antenna:
    a. Type: Flanged encapsulated antenna.

b. Flange Size: 8-inch minimum nominal pipe size. Provide flange that shall comply with EN 1092-1, ASME B16.5, or JIS B2238 bolt pattern as applicable. Coordinate flange size, rating, and bolt pattern with pipe onto which flange is mounted. Provide flange size and mounting pipe size as required to ensure the connecting pipe length as shown on the PLANS does not interfere with the transducer signal/beam angle. Refer to the PLANS for additional requirements.
c. Flange Material: Type 316L Stainless Steel.
d. Flange Bolting Hardware: Type 316 Stainless Steel bolts, nuts and washers.

2.06 ULTRASONIC CLAMP-ON FLOW ELEMENT AND INDICATING TRANSMITTERS

A. F713: Ultrasonic Clamp-On Flow Element and Indicating Transmitters
1. General Requirements:
a. The instrument shall be a clamp-on type ultrasonic flow sensing elements with transmitter and factory supplied sensor-transmitter interconnecting cables.
b. The instrument sensor element shall produce ultrasonic sound waves through the process fluid carrier pipe and within the process fluid flow, measure a flow rate based on the transit time difference principle and generate a signal directly proportional to the process fluid flow rate.
c. Furnish and install the clamp-on type ultrasonic flow sensors, transmitter, interconnecting cables, transmitter mounting hardware, element pipe mounting hardware, element coupling pads, and accessories.
d. Provide calibration traceable to NIST and A2LA/ISO 17025.
2. Measurement Characteristics:
a. Process Fluid Flow Velocity Range: 0.03 to 82 feet per second, minimum.
b. Repeatability: 0.15% of measurement reading +/- 0.03 feet per second, minimum.
c. Accuracy of Velocity Measurement:
1) +/- 0.5% of reading +/- 0.03 feet per second, minimum.
2) Provide all required field calibration services as required by the manufacturer to achieve the above stated accuracy.
d. Number of Flow Measuring Channels: Two (2).
e. Signal Attenuation: 0 to 100 seconds, adjustable.
f. Measuring Cycle (per channel): 100 to 1000 Hz.
g. Response Time: 70 milliseconds.
h. Measurement Configuration Capabilities:
1) Configure the instrument to provide the measurement in units as listed in the Appendix A Instrument List.
2) At a minimum, the unit shall have the following measurement function capabilities:
a) Physical Quantities: Volumetric flow rate, mass flow rate, and flow velocity.
b) Totalizer: Volume and mass.
c) Calculation Functions: Average, difference, and sum.
d) Diagnostic Functions: Sound speed, signal amplitude, SNR, SCNR, standard deviation of amplitudes and transit times.
3. Flow Indicating Transmitter:
a. Transmitter Power Supply: 100 to 230 V at 60 Hz.

b. Transmitter Power Consumption: 15 Watts, maximum.
c. Transmitter Housing:
    1) Material: Type 316L Stainless Steel.
    2) Enclosure Rating: NEMA 4X, minimum.
    3) Explosion Protection Marking: NI/Cl. I,II,III/Div. 2/GP. A,B,C,D,E,F,G/T5 Ta = 60 degrees-Celsius.
d. Transmitter Environmental Operating Range: -4 to +140 degrees-Fahrenheit.
e. Transmitter Display Interface: 2 x 16 characters minimum, backlight.
f. Transmitter Input Interface: Keypad to allow all required configuration and settings of unit without the need of an external device.
g. Transmitter Data Logger:
    1) Loggable Values: All physical quantities, totalized values and diagnostic values.
    2) Capacity: Greater than 100,000 measured values.
h. Transmitter Signal Outputs:
    1) Two (2) Analog outputs, each having the following:
        a) Range: 0 to 20 mA.
        b) Accuracy: 0.1 % of reading +/-15 µA.
    2) Three (3) Discrete outputs, each having the following:
        a) Solid state output relay to be field configured as desired for the Owner for discrete outputs, including errors, minimum flow rates, change in direction and/or other conditions.
        b) Type (holding behavior): Non-hold or hold.
        c) Mode (switching function): Normally open or normally closed.
        d) As a minimum, configure one (1) of the discrete output relays as a general system error/fault alarm.
i. Transmitter Mounting: Wall mounting or on 2-inch pipe as shown on the PLANS.

4. Flow Element Transducers:
    a. General: Provide the type and frequency of clamp-on transducers within the available series of products as offered by the manufacturer for the specific instrument as recommended by the manufacturer to yield the greatest accuracy for the required flow measurements range and the process fluid pipe dimensions.
    b. Transducer frequency minimum requirements for process fluid inner pipe diameter:
        1) Inner Pipe Diameter of 7.9 to 141.7 inches: 0.5 MHz.
        2) Inner Pipe Diameter of 3.9 to less than 7.9 inches: 1.0 MHz.
        3) Inner Pipe Diameter of 2.0 to less than 3.9 inches: 2.0 MHz.
        4) Inner Pipe Diameter of 0.98 to less than 2.0 inches: 4.0 MHz.
        5) Inner Pipe Diameter of less than 0.98 inches: 8.0 MHz.
    c. Refer to the PLANS for the process fluid pipe dimensions.
    d. Transducer Housing:
        1) Material: Type 316L Stainless Steel.
        2) Enclosure Rating: Provide NEMA 6 minimum for all listed frequencies except for 8.0 MHz. For 8.0 MHz, provide NEMA 4 minimum.
        3) Explosion Protection Marking: NI/Cl. I,II,III/Div. 2 /GP A,B,C,D,E,F,G/Temp. Codes dwg 3860.
    e. Environmental Operating Range: Range: -40 to 266 degrees-Fahrenheit, minimum.

f. Transducer Contact Surface: Provide PEEK for all listed frequencies except for 8.0 MHz. For 8.0 MHz, provide PEI.
g. Transducer Cables:
    1) Ambient Temperature Range: -148 to 437 degrees-Fahrenheit.
    2) Sheath: Type 316L Stainless Steel with 0.31-inch outer diameter.
    3) Cable Jacket: PFS having a 0.11-inch outer diameter and 0.02-inch minimum thickness.
h. Transducer Mounting Hardware:
    1) Material: Type 316L Stainless Steel
    2) Type: Track and strapping. Provide required direct/reflect mount installation in two tracks having an inner rail length and installation as required/suitable for the transducer installations and process pipe diameter for a complete and secure installation.

5. Coupling Pad Materials for Transducers:
    a. Minimum Requirements:
        1) Type: Foil with fluoroelastomer material.
        2) Coupling Pad Temperature Range: 14 to 392 degrees-Fahrenheit, minimum.
    b. General: Provide the type coupling pad material within the available series of products as offered by the manufacturer for the specific instrument as recommended by the manufacturer to yield the greatest accuracy for the required flow measurements range and specified coupling pad temperature range.
6. Sensor-Transmitter Interconnecting Cables and Junction Box:
    a. Sensor-transmitter cables shall be furnished by the manufacturer and as required for the length of the installation.
    b. Coordinate the length with the requirements of the PLANS. Provide sufficient cable length to allow a minimum of 40-inches of slack near each sensor. Wrap slack cable neatly in a 12” diameter bundle and secure to cable conduit raceway with a plastic zip tie. The ICS shall coordinate the installation of the instrument with the Electrical Contractor prior to the installation/routing/and system requirements of the raceway/conduit system in the facility.
    c. The cable wiring termination shall be direct termination from the sensor module to the Indicator/Transmitter/Controller module. The sensor shall be supplied with sufficient length of cable for connection to the Indicator/Transmitter/Controller module without any cable splices.
        1) Exception: Splice shall only be allowed if the required transducer consists of a cable length that requires an extension cable to comply with the installed conditions and as shown on the PLANS and the specified 10 feet of slack near each sensor. For such condition, provide the required extension cables, terminations and a factory furnished junction box having a NEMA 6 rating with silicone gasket, constructed of Type 316 Stainless Steel and suitable for and 2-inch pipe mounting. Mount the junction box on a 2-inch pipe stand near the process pipe connection. Clearly locate the junction box on the submittal drawings/document and coordinate with field conditions.
    d. Run Transducer cable (through conduit system and as shown on PLANS) direct from transducer to the Indicator/Transmitter/Controller without any cable splices.

7. The Ultrasonic Clamp-On Flow Element and Indicating Transmitter along with the associated interconnecting cables, and transmitter mounting hardware, element pipe mounting hardware, and accessories shall be as manufactured by Flexim Model ADM 7407.316SE flow indicating transmitter, Series FS ultrasonic transducers with Type 6111 transducer cables, applicable Type 2615 transducer extension cables, PermaLok PL Mounting Track transducer mounting kits, Type VT coupling plate foils, applicable Model JBP3 junction box, and specified accessories, or Engineer approved equal.

2.07 DIGITAL LOOP POWERED INDICATORS

A. I107 Requirements
   1. Display:
      a. 3 and 1/2 digit, 1.0 inch high bright Liquid Crystal Display (LCD).
      b. Watertight/gastight and corrosion resistant lens that will enable reading the indictor display without opening any cover door of the indicator's enclosure/housing.
   2. Input Signal:
      a. 4-20mA at 24VDC
      b. Signal proportional to the process variable measured.
   3. Units:
      a. 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.).
      b. The engineering units shall be permanently marked on the surface of the indicator.
      c. Refer to Appendix A Instrument List for additional information.
   4. Readout Accuracy: Plus or minus 0.1 percent of calibrated span plus or minus 1 count.
   5. Calibration Range:
      a. 4 ma input: -1000 to +1000 display.
      b. 20 ma input: between 20 to 2000 counts greater than 4 ma display.
   6. Voltage Drop: 1 VDC maximum at 20 mA.
   7. Conversion Rate: 2.5 conversions per second.
   8. Calibration:
      a. Two-step, non-interacting zero and span.
      b. Indicator and enclosure assembly zero and span adjustment shall be external to the indicator housing/enclosure such that zero and span shall be adjusted externally without opening any cover/door of the indicator's enclosure/housing.
   9. Enclosure:
      a. NEMA 3, 4, 7 and 9 rated.
      b. Corrosion resistant and watertight/gas-tight.
      c. Explosion-proof cast aluminum housing.
      d. FM approval.
   10. Nameplate: Each indicator shall be equipped with an engraved nameplate that will display the total range of the indicator. This information may be incorporated on the instrument identification nameplate.
   11. Operating Temperature: -40 to +176 degrees Fahrenheit.
   12. Power: Two-wire loop powered.

13. Wiring Connections:
    a. 3/4" NPT male conduit hub connection.
    b. Terminal block inside enclosure.
14. Mounting: Manufacturer furnished Type 316 Stainless Steel mounting bracket kit and as required for installation shown on PLANS.
15. Each Indicator shall be as manufactured by Precision Digital Model PD6870 complete with specified accessories or Engineer approved equal.

2.08 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. Bleed Fitting/Valve:
1. Type: Swage ferrule or threaded process connection, as suited for application. Include vent tube and back stop screw. Provide handle. Provide barbed ventu tube where vent tube is piping to drain or other location where shown on PLANS.
2. Material: Type 316 Stainless Steel
3. Stem O-Ring: Fluoroelastomer.
4. Size: Same size as tubing

5. Pressure Rating: Same as tubing
6. Manufacturer: Crawford "Swagelok", Parker "CPI", Hoke "Gyrolok", or Engineer approved equal.

F. Provide stainless steel reducer/transition fittings at instrument/process piping and tubing connections.

G. 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.

H. 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.
      d. Where tubing/piping is larger than 1" diameter, provide 1" size vent screen fitting and necessary reducer fitting to connect to tubing/piping.
   3. Pressure Rating: Same as tubing
   4. Fitting: Screen, Hoke SCRN or Engineer approved equal.
   5. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.

I. Provide stainless steel rigid to plastic flexible tubing transitions where shown on PLANS including stainless steel tube inserts and Teflon ferrule compression fitting.

J. 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

2.09 WIRE MESH GRIPS

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.

2.10 HOODS (SUN-SHIELDS)

A. Furnish and install an aluminum HOOD (Sun-Shield) on top of each Enclosure/Panel, Indicator Instrument, Transmitter Instrument, Indicating/Transmitter Instrument, Analyzer Instrument, Controller Instrument, Instrument Element and Field Control Station that is mounted OUTDOORS and/or mounted within/below a vault/structure such that it receives direct sunlight through an opening in the vault/structure:
   1. Where the term Sun-Shield is used on the PLANS and specifications, it shall imply HOOD as noted herein.
   2. Aluminum HOOD installation shall apply for all field instrumentation installed OUTDOORS, inclusive of field instrumentation specified in this Section and specified in other applicable portions of the PLANS and specifications to be provided as part of this Work, including, but not limited to, Divisions 11, 13, 15, 16 and 17 Specification Sections as applicable, other equipment specifications sections including instruments specified or provided by equipment manufacturers, and/or as shown on the PLANS.
   3. Support the HOOD via channel supports that are separate from and independent of the instrument, instrument flange mounting assembly and/or instrument support channels/rack/pipe. Secure the HOOD to the support channels utilizing 316 Stainless Steel hardware. Provide all mounting hardware necessary for the installation of the Hood Assembly. Refer to the PLANS.
   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 except where a mechanical hinge is noted.
   5. Furnish and install a hinged front door/cover on the face of the HOOD to protect the front (full height and width) of the instrument/field control station/panel inside the HOOD. The door shall extend down to the bottom of the proposed instrument or field control station/panel. The door shall swing out through a minimum 180-degree of rotation in plan view.
      a. Secure the side of the door to the HOOD with a continuous aluminum piano hinge that is welded via a continuous aluminum weld to the side of the HOOD and a continuous aluminum weld to the front door/cover. The piano hinge shall be constructed of 0.09-inch thick minimum 3003-H14 sheet (ASTM B209) aluminum, having a 2-inch minimum open width, a length equal to the full height of the HOOD door/cover and as manufactured by Monroe of Rochester Hills, Michigan or Engineer

approved equal. The width of the door shall equal the finished outside edge-to-edge dimension of the hood to ensure that when the door is in the closed position the door is stopped by and rests onto the side edge of the hood.

b. Provide a bolt latch with a surface strike to allow the user to lock the door in the closed position. The bolt latch and surface strike shall each be constructed of Type 304 Stainless Steel as manufactured by Sugatsune, Item Number SSG-85 or Engineer approved equal. Fasten the bolt latch onto the door such that the operable bolt travels in the horizontal direction, towards the surface strike and with the bottom edge of the bolt latch positioned 1-inch above the bottom edge of the door. The surface strike shall be fastened on an aluminum sheet mounting plate having the same material and thickness as the hood and welded onto one the side of the hood. Provide six (6) sets of Type 316 Stainless Steel size #10 minimum diameter bolts, nuts and locking washers and use four (4) of the sets to fasten the latch onto the door and two (2) of the sets to fasten the surface strike onto the extended surface off the side of the hood. Size each bolt such that the threaded length extends no more than 1/4-inch past the nut.

c. Refer to the PLANS for additional requirements.

6. Provide a mock-up of the HOOD (Sun-Shield) as follows for review by the OWNER and ENGINEER:
   a. Upon completion of the review and comment of the HOOD (Sun-Shield) shop drawing(s) by the OWNER and ENGINEER, fabricate and submit a mock-up of a complete HOOD (Sun-Shield) assembly for additional review and comment by the OWNER and ENGINEER prior to fabricating the required quantity of HOODS (Sun-Shields) to be installed as part of this Work.
   b. The size of the mock-up shall be based on an instrument or field control station/panel that is 6-inches wide, by 6-inches tall, and by 4-inches deep.
   c. The HOOD (Sun-Shield) mock-up shall be in addition to the quantity of HOODS (Sun-Shields) to be installed as part of the final Work as required per the specifications, the Instrument List and/or as shown on the PLANS.
   d. The following elements are not required as part of the mock-up:
      1) The instrument and/or control station/panel to be installed inside the HOOD (Sun-Shield).
      2) The support elements/channels on which the HOOD (Sun-Shield) is fastened as shown on the Drawings.
   e. Refer to the mock-up requirements in this section for additional requirements.

B. Refer to PLANS for additional requirements for construction and mounting of HOOD.

2.11 STAND-PIPES

A. Where PLANS show a stand-pipe (also referred to as a stilling-well), provide the following pipe, flange and blind flange components:
   1. Indoor Applications not Exposed to Sunlight:
      a. The stand-pipe shall be an ASTM D 1784 Schedule 80 PVC Pipe of diameter and length as shown on PLANS. Manufactured by Havel Pipe or Engineer approved equal.

b. Provide an ASTM D 1784 Schedule 80 single piece socket flange fitting with slip-on solvent weld connection to pipe. Carefully apply solvent so as not to drip past fitting. Flange shall be Class 150 ANSI B16.5. Flange diameter to match stand-pipe diameter shown on PLANS. Manufactured by NIBCO or Engineer approved equal.
c. Provide a Type 316 Stainless Steel Schedule 40 Blind Flange with Type 316 Stainless Steel bolts, washers, and nuts hardware assembly to fasten blind flange to flange fitting. Pipe flange and blind flange bolt patterns shall match. Blind flange cap diameter to match stand-pipe diameter shown on PLANS. Manufactured by Warren Alloy or Engineer approved equal.
d. Fabricate a handle made of the same material as the blind flange and welded to the top face of the blind flange. Refer to the PLANS for additional requirements, including blind flange handle geometry.

2. Outdoor and/or Sunlight Applications:
   a. Where stand-pipe is mounted outdoor and/or under sun light, the stand-pipe shall be an ASTM B 221 Schedule 40 Type 6061-T6 Schedule 40 Extruded Aluminum Pipe of diameter and length as shown on PLANS.
   b. Provide a Type 6061-T6 Aluminum Flange with full aluminum welded connection to pipe. Flange shall be Class 150 ANSI B16.5. Flange diameter to match stand-pipe diameter shown on PLANS.
   c. Provide a 6061-T6 Stainless Steel Schedule 40 Blind Flange with Type 316 Stainless Steel bolts, washers, and nuts hardware assembly to fasten blind flange to flange fitting. Pipe flange and blind flange bolt patterns shall match. Blind flange cap diameter to match stand-pipe diameter shown on PLANS.
   d. Fabricate a handle made of the same material as the blind flange and welded to the top face of the blind flange. Refer to the PLANS for additional requirements, including blind flange handle geometry.
3. Stand-pipe mounting hardware and support brackets shall be manufactured from Type 316 Stainless Steel. Refer to the details on the PLANS.

2.12 SUPPORTS SYSTEMS CONSTRUCTED OF PIPES AND PIPE FITTINGS

A. Where pipes are shown on the PLANS as support elements in lieu of support channels, the pipe and pipe fitting components of the support systems shall be Type 316L Stainless Steel with welded joints and constructed as follows:
   1. Materials of Construction: Type 316L Stainless Steel. All Stainless Steel Sheet and Plate shall be extra low carbon (0.03% maximum) and meet ASTM/ASME standards. All welding shall conform to material requirements.
   2. Finish: Number 1 Hot-Rolled Annealed and Pickled. After all shop operations have been completed, all stainless steel material shall be pickled and passivated (completely immersed for a minimum of 15 minutes in 10% nitric acid and 3% hydrofluoric acid at 125˚F, followed by a neutralizing rinse).
   3. Wall Thickness: Schedule 40S per ASTM A-312/ASME SA-312.
   4. Welding: All welding shall be per GTAW, GMAW and plasma arc welding processes. All welders shall be ASME qualified welders and shall use ASME procedures designed to provide full penetration welds. Automatic or semi-automatic positioning fixtures shall be used on pipe and fittings. Interior surfaces shall be smooth, even and uniform.

5. Pipe: All pipe elements shall conform to ASTM A-778, A-312, A-358, A-269 or A-249 specifications unless otherwise noted.
6. Fittings: All pipe fittings shall conform to ASTM A-403 or A-774 specifications unless otherwise noted. Fittings shall conform to ANSI B16.9/MSS SP 43 requirements. Applicable fittings include, but are not limited to:
    a. 90 degree elbows,
    b. 45 degree elbows,
    c. 45 degree laterals,
    d. Tees and wyes,
    e. Reducers, and
    f. Caps.
7. Dimensions: Applicable elements shall be manufactured to MSS dimensions.
8. Marking: All pipe and fittings shall be marked in accordance with the requirements of the pertinent ASTM/ASME standard.
9. Manufacturer Quality Program and Certifications: The pipe and fitting manufacturer quality system shall be registered to the ISO 9001 standard and shall have an ANSI/ANAB accredited third party auditor. The quality program shall utilize, as a minimum, the following inspection and test methods:
    a. Liquid penetrant,
    b. Eddy current,
    c. X-ray, and
    d. Hydrostatic.
10. Shipping: Materials shall be crated. All plain ends shall be plugged and flanged ends shall be wired to protect lap ring surface.
11. Flanges: Shall be solid Type 316L Stainless Steel per ANSI B16.5 and ASTM A182F, forged slip-on welded onto the pipe/fitting at the factory, flat faced, and 150 pound class pressure rating unless noted otherwise.
    a. As an option to the fabricator, flanges may be weld-neck butt-welded in lieu of slip-on welded.
    b. Provide raised faced flange in lieu of flat faced when required for a specific valve/equipment connection.
    c. Flange face shall be machined smooth to accept gasket.
        1) Serrated face flanges are NOT acceptable.
        2) Angle face rings and backer flanges are NOT acceptable.
12. Hardware and gaskets: Type 316 Stainless Steel bolts, washers, and nuts of sufficient size and construction suitable for the class pressure rating on the flange which hardware is installed in accordance with ANSI B16.5 requirements.

B. Pipe and fitting components shall be as manufactured by Felker Brothers Corporation with all specified options and accessories, or Engineer approved equal.

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, cush-a-clamp assembly pipe/tube clamp, all instrument tubing channels and their support elements, etc. shall be Type 316 Stainless Steel. Refer to Division 16 Specifications for additional support system requirements.
   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).
      a. All proposed instruments shall receive new permanent identification.
      b. All existing instruments shown on the PLANS that are to be relocated and/or to receive new wiring for signals/power/etc. as part of this Work shall also receive new permanent identification. Remove the existing identification tags from existing instruments that are to receive new tags.
   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 instruments.

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 be 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.
17. Furnish and install an aluminum HOOD (Sun-Shield) on top of each Enclosure/Panel, Indicator Instrument, Transmitter Instrument, Indicating/Transmitter Instrument, Analyzer Instrument, Controller Instrument, Instrument Element and Field Control Station that is mounted OUTDOORS and/or mounted within/below a vault/structure such that it receives direct sunlight through an opening in the vault/structure. Refer to the PRODUCTS PART 2 Section of this specification and the PLANS for additional requirements on the construction and installation of each HOOD.
18. Where piping is provided as a support element in lieu of support channels, including, but not limited to, 2-inch diameter pipe posts, all open ends of piping shall be capped with a welded cap having the same material and diameter as the piping. Refer to the PRODUCTS PART 2 Section of this specification and the PLANS for additional requirements.
19. For each instrument specified in this section that includes an integral display screen/indicator and/or user interface button(s), unless indicated otherwise on the Drawings, install the instrument such that the top of the display screen/indicator and/or user interface button(s) is as high as possible but no greater than 60 inches above the finished floor of the working area immediately adjacent to the instrument. Refer to the Drawings for additional requirements. Refer to additional installation height requirements for each specific instrument as specified in this section.
    a. Note: For each instrument that includes an instrument tubing connection, refer to the applicable instrument tubing installation requirements in this section for the required slope of the instrument tubing and other additional requirements that impact the installed height of the instrument.

B. 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.

C. Radar 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.
   2. Program instrument to filter out interference of side walls inside wells/tanks/containers to maximize level accuracy of instrument.
   3. Configure the instrument via the instrument manufacturer local instrument buttons/keys and as required via the instrument manufacturer configuration software from a computer or other digital device for instrument start-up and measurement optimization.

D. 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.

E. Ultrasonic Clamp-On Flow Element and Indicating Transmitters:
1. Where multiple flow elements are specified for each flow transmitter, position the clamp-on transducers on the pipe and configure the transmitter as recommended by the instrument manufacturer to provide the highest possible accuracy for the given process fluid characteristics, flow/velocity range, pipe upstream and downstream obstructions/fittings/valves and other conditions present in the piping systems.
2. The possible arrangements for the clamp-on elements include, but are not limited to:
a. Reflect Arrangement: The number of sound paths is even. Both of the transducers are mounted on the same side of the pipe.
b. Diagonal Arrangement: The number of sound paths is odd. Both of the transducers are mounted on opposite sides of the pipe.
c. Direct Mode: Diagonal mode with one sound path. This may be used in the case of a relatively high signal attenuation by the medium, pipe or coatings, as recommended by the instrument manufacturer.

F. 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 Flexible Capillary and Rigid Tubing):
a. Support all instrument tubing by channel support systems. As a minimum, support all instrument tubing as follows:
1) Gas and Liquid Tubing: Clamp tubing onto channel support systems with tubing clamps spaced at no greater than 2’-6” intervals on horizontal and vertical runs, and no greater than 3” from each instrument tubing elbow and tee fitting.

2) Capillary Tubing: Route capillary tubing inside channels.
a) After installing the tubing in the open channels, cover as much of the open face of the channels as possible with segments of 1/8” thick cover plates constructed of the same material as the channel. Each cover plate shall be cut to 23 inches maximum in length, and the width of the plate shall match the width of the channel. Secure the cover plates to the channels with channel hardware and fittings.
b) Refer to the PLANS for additional capillary channel requirements.
3) Refer to the 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/equipment tap connection shall be sloped 10% up towards the process pipe/equipment connection.
c. Tubing installed higher than the process pipe/equipment 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/equipment 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/equipment tap connection shall be sloped 10% down towards the process pipe/equipment connection.
c. Tubing installed lower than the process pipe/equipment tap connection, shall have a condensate drip leg and drain valve. Drip leg pipe segment shall be 6” long and located at the lowest portion of the instrument tubing. Install horizontal segments of the instrument tubing at a 10% slope down towards the 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.

G. 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.
   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 trouble-shooting, 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.
      d. Refer to instrument by Instrument Type Code as listed in this specification section where applicable.

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 17380 APPENDIX A

WALNUT CREEK WWTP PUMPING SYSTEMS IMPROVEMENTS INSTRUMENT LIST

INSTRUMENT TAG	INST. TYPE CODE	SPEC. SECT.	PROCESS AREA	COMPONENT TITLE	MIN. VALUE	MAX. VALUE	MEAS. UNIT	INSTALLATION DETAIL DRAWING	PLAN DRAWING	WIRING SCHEMATIC DRAWING	P&ID DRAWING	COMMENTS
OP-PIT-1641-01	P131	17380	OPERATIONS BUILDING	SETTLED WASTEWATER PUMP NO. 1 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	45	PSI	[TD-I-003]	[OP-E-055] [OP-E-067]	[OP-I-016]	[OP-I-002]	
OP-PIT-1641-02	P131	17380	OPERATIONS BUILDING	SETTLED WASTEWATER PUMP NO. 2 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	45	PSI	[TD-I-003]	[OP-E-055] [OP-E-067]	[OP-I-016]	[OP-I-002]	
OP-PIT-1641-03	P131	17380	OPERATIONS BUILDING	SETTLED WASTEWATER PUMP NO. 3 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	45	PSI	[TD-I-003]	[OP-E-055] [OP-E-067]	[OP-I-016]	[OP-I-002]	
OP-PIT-1641-04	P131	17380	OPERATIONS BUILDING	SETTLED WASTEWATER PUMP NO. 4 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	45	PSI	[TD-I-003]	[OP-E-055] [OP-E-067]	[OP-I-016]	[OP-I-002]	
OP-PIT-1641-05	P131	17380	OPERATIONS BUILDING	SETTLED WASTEWATER PUMP NO. 5 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	45	PSI	[TD-I-003]	[OP-E-055] [OP-E-067]	[OP-I-016]	[OP-I-002]	
OP-PIT-1641-06	P131	17380	OPERATIONS BUILDING	SETTLED WASTEWATER PUMP NO. 6 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	35	PSI	[TD-I-003]	[OP-E-054] [OP-E-066]	[OP-I-016]	[OP-I-003]	
OP-PIT-1641-07	P131	17380	OPERATIONS BUILDING	SETTLED WASTEWATER PUMP NO. 7 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	35	PSI	[TD-I-003]	[OP-E-054] [OP-E-066]	[OP-I-016]	[OP-I-003]	
OP-PIT-1641-08	P131	17380	OPERATIONS BUILDING	SETTLED WASTEWATER PUMP NO. 8 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	35	PSI	[TD-I-003]	[OP-E-054] [OP-E-066]	[OP-I-016]	[OP-I-003]	
OP-LSH-1660	L301	17380	OPERATIONS BUILDING	OPERATIONS BUILDING FLOOD ALARM	0	7	FT	[TD-I-003]	[OP-E-067]	[OP-I-018]	[OP-I-002]	
OP-FIT-1673-01 OP-FE-1673-01A OP-FE-1673-01B	F713	17380	OPERATIONS BUILDING	SETTLED WASTEWATER FLOW INDICATING TRANSMITTER (EXISTING REINSTALLED)	10	200	MGD	N/A	[OP-E-051]	[OP-I-015]	[OP-I-002]	
OP-FIT-1673-02 OP-FE-1673-02A OP-FE-1673-02B	F713	17380	OPERATIONS BUILDING	SETTLED WASTEWATER FLOW INDICATING TRANSMITTER	10	200	MGD	N/A	[OP-E-051]	[OP-I-015]	[OP-I-002]	
OP-LIT-1675-01 OP-LIC-1675-01	P104 N/A	17380 17200	OPERATIONS BUILDING	RAW WASTEWATER WET WELL LEVEL INDICATING TRANSMITTER	0	18	FT	[TD-I-004]	[OP-E-050]	[OP-I-019]	N/A	
OP-LIC-1675-02	N/A	17200	OPERATIONS BUILDING	RAW WASTEWATER WET WELL LEVEL INDICATING/SETPOINT CONTROLLER	0	18	FT	[TD-I-004]	N/A	[OP-I-020]	N/A	

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OP-TIT-1692 OP-TE-1692	T118	17380	OPERATIONS BUILDING	NON POTABLE WATER HEAT EXCHANGER COOLANT SUPPLY TEMPERATURE INDICATING TRANSMITTER	32	212	DEG F	[TD-I-001]	[OP-E-070]	[OP-I-012]	[OP-I-004]	
OP-TIT-1693 OP-TE-1693	T118	17380	OPERATIONS BUILDING	NON POTABLE WATER HEAT EXCHANGER COOLANT RETURN TEMPERATURE INDICATING TRANSMITTER	32	212	DEG F	[TD-I-001]	[OP-E-070]	[OP-I-012]	[OP-I-004]	
OP-PIT-1694	P104	17380	OPERATIONS BUILDING	NON POTABLE WATER HEAT EXCHANGER COOLANT RETURN PRESSURE INDICATING TRANSMITTER	0	120	PSI	[TD-I-003]	[OP-E-070]	[OP-I-013]	[OP-I-004]	
OP-FIT-1695 OP-FE-1695	N/A	17511	OPERATIONS BUILDING	NON POTABLE WATER HEAT EXCHANGER COOLANT RETURN TO FLOW EQUALIZATION BASIN FLOW INDICATING TRANSMITTER	0	1400	GPM	[TD-I-001]	[OP-E-070]	[OP-I-013]	[OP-I-004]	
OP-FIT-1696 OP-FE-1696	N/A	17511	OPERATIONS BUILDING	NON POTABLE WATER HEAT EXCHANGER COOLANT RETURN TO CHLORINE EJECTORS FLOW INDICATING TRANSMITTER	0	1400	GPM	[TD-I-001]	[OP-E-070]	[OP-I-013]	[OP-I-004]	
OP-TIT-1697	T103	17380	OPERATIONS BUILDING	OPERATIONS BUILDING ELECTRICAL ROOM AMBIENT AIR TEMPERATURE INDICATING TRANSMITTER	32	122	DEG F	[TD-I-001]	[OP-E-068]	[OP-I-016]	[OP-I-003]	
PTC1-LIT-3711 PTC1-LE-3711	L205	17380	PRIMARY TREATMENT COMPLEX NO. 1	PRIMARY CLARIFIER NO. 1 SLUDGE BLANKET LEVEL INDICATING TRANSMITTER	0	14	FT	[TD-I-002]	[PTC1-E-005]	[PTC1-I-010]	[PTC1-I-001]	
PTC1-LIT-3721 PTC1-LE-3721	L205	17380	PRIMARY TREATMENT COMPLEX NO. 1	PRIMARY CLARIFIER NO. 2 SLUDGE BLANKET LEVEL INDICATING TRANSMITTER	0	14	FT	[TD-I-002]	[PTC1-E-005]	[PTC1-I-010]	[PTC1-I-001]	
PTC2-LIT-3731 PTC2-LE-3731	L205	17380	PRIMARY TREATMENT COMPLEX NO. 2	PRIMARY TREATMENT COMPLEX NO. 2 PRIMARY BASIN NO. 3 SLUDGE BLANKET LEVEL INDICATING TRANSMITTER	0	14	FT	[TD-I-002]	[PTC2-E-022] [PTC2-E-026]	[PTC2-I-011]	[PTC2-I-001]	
PTC2-LIT-3741 PTC2-LE-3741	L205	17380	PRIMARY TREATMENT COMPLEX NO. 2	PRIMARY TREATMENT COMPLEX NO. 2 PRIMARY BASIN NO. 4 SLUDGE BLANKET LEVEL INDICATING TRANSMITTER	0	14	FT	[TD-I-002]	[PTC2-E-022] [PTC2-E-026]	[PTC2-I-011]	[PTC2-I-001]	
FEC1-PIT-3801 FEC1-PI-3801	P125	17380	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SLUDGE DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC1-E-011]	[PTC1-I-009]	[PTC1-I-003]	
FEC1-AIT-3802 FEC1-AE-3802	N/A	17502	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 TOTAL SLUDGE SUSPENDED SOLIDS ANALYSIS INDICATING TRANSMITTER	0.01	500	g/l	[TD-I-002]	[PTC1-E-011]	[PTC1-I-009]	[PTC1-I-003]	

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FEC1-PIT-3811 OP-PIC-3811	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SLUDGE PUMP NO. 1 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC1-E-007] [PTC1-E-011]	[PTC1-I-007]	[PTC1-I-003]	
FEC1-AIT-3812 FEC1-AE-3812	N/A	17502	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SLUDGE PUMP NO. 1 DISCHARGE SUSPENDED SOLIDS ANALYSIS INDICATING TRANSMITTER	0.01	500	g/l	[TD-I-002]	[PTC1-E-007] [PTC1-E-011]	[PTC1-I-009]	[PTC1-I-003]	
FEC1-PIT-3821 OP-PIC-3821	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SLUDGE PUMP NO. 2 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC1-E-007] [PTC1-E-011]	[PTC1-I-007]	[PTC1-I-003]	
FEC1-AIT-3822 FEC1-AE-3822	N/A	17502	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SLUDGE PUMP NO. 2 DISCHARGE SUSPENDED SOLIDS ANALYSIS INDICATING TRANSMITTER	0.01	500	g/l	[TD-I-002]	[PTC1-E-007] [PTC1-E-011]	[PTC1-I-009]	[PTC1-I-003]	
FEC1-PIT-3831 OP-PIC-3831	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SLUDGE PUMP NO. 3 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC1-E-007] [PTC1-E-011]	[PTC1-I-007]	[PTC1-I-003]	
FEC1-AIT-3832 FEC1-AE-3832	N/A	17502	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SLUDGE PUMP NO. 3 DISCHARGE SUSPENDED SOLIDS ANALYSIS INDICATING TRANSMITTER	0.01	500	g/l	[TD-I-002]	[PTC1-E-007] [PTC1-E-011]	[PTC1-I-009]	[PTC1-I-003]	
FEC2-PIT-3901 FEC2-PI-3901	P125	17380	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SLUDGE DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC2-E-024] [PTC2-E-028]	[PTC2-I-010]	[PTC2-I-003]	
FEC2-AIT-3902 FEC2-AE-3902	N/A	17502	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SLUDGE SUSPENDED SOLIDS ANALYSIS INDICATING TRANSMITTER	0.01	500	g/l	[TD-I-002]	[PTC2-E-024] [PTC2-E-028]	[PTC2-I-009]	[PTC2-I-003]	
FEC2-PIT-3911 FEC2-PIC-3911	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SLUDGE PUMP NO. 1 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC2-E-024] [PTC2-E-028]	[PTC2-I-008]	[PTC2-I-003]	
FEC2-AIT-3912 FEC2-AE-3912	N/A	17502	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SLUDGE PUMP NO. 1 DISCHARGE SUSPENDED SOLIDS ANALYSIS INDICATING TRANSMITTER	0.01	500	g/l	[TD-I-002]	[PTC2-E-024] [PTC2-E-028]	[PTC2-I-009]	[PTC2-I-003]	

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FEC2-PIT-3921 FEC2-PIC-3921	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SLUDGE PUMP NO. 2 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC2-E-024] [PTC2-E-028]	[PTC2-I-008]	[PTC2-I-003]	
FEC2-AIT-3922 FEC2-AE-3922	N/A	17502	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SLUDGE PUMP NO. 2 DISCHARGE SUSPENDED SOLIDS ANALYSIS INDICATING TRANSMITTER	0.01	500	g/l	[TD-I-002]	[PTC2-E-024] [PTC2-E-028]	[PTC2-I-009]	[PTC2-I-003]	
FEC2-PIT-3931 FEC2-PIC-3931	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SLUDGE PUMP NO. 3 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC2-E-024] [PTC2-E-028]	[PTC2-I-008]	[PTC2-I-003]	
FEC2-AIT-3932 FEC2-AE-3932	N/A	17502	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SLUDGE PUMP NO. 3 DISCHARGE SUSPENDED SOLIDS ANALYSIS INDICATING TRANSMITTER	0.01	500	g/l	[TD-I-002]	[PTC2-E-024] [PTC2-E-028]	[PTC2-I-009]	[PTC2-I-003]	
PTC1-LIT-4011 PTC1-LE-4011 FEC1-LI-4011 OP-LIC-4011	L718 - I107 N/A	17380 - 17380 17200	PRIMARY TREATMENT COMPLEX NO. 1	PRIMARY TREATMENT COMPLEX NO. 1 PRIMARY BASIN NO. 1 SCUM PIT LEVEL INDICATING TRANSMITTER	0	17	FT	[TD-I-004]	[PTC1-E-005]	[PTC1-I-007]	[PTC1-I-001]	
PTC1-LIT-4021 PTC1-LE-4021 FEC1-LI-4021 OP-LIC-4021	L718 - I107 N/A	17380 - 17380 17200	PRIMARY TREATMENT COMPLEX NO. 1	PRIMARY TREATMENT COMPLEX NO. 1 PRIMARY BASIN NO. 2 SCUM PIT LEVEL INDICATING TRANSMITTER	0	17	FT	[TD-I-004]	[PTC1-E-005]	[PTC1-I-007]	[PTC1-I-001]	
PTC2-LIT-4031 PTC2-LE-4031 FEC2-LI-4031 FEC2-LIC-4031	L718 - I107 N/A	17380 - 17380 17200	PRIMARY TREATMENT COMPLEX NO. 2	PRIMARY TREATMENT COMPLEX NO. 2 PRIMARY BASIN NO. 3 SCUM PIT LEVEL INDICATING TRANSMITTER	0	17	FT	[TD-I-004]	[PTC2-E-024] [PTC2-E-026] [PTC2-E-028]	[PTC2-I-008]	[PTC2-I-001]	
PTC2-LIT-4041 PTC2-LE-4041 FEC2-LI-4041 FEC2-LIC-4041	L718 - I107 N/A	17380 - 17380 17200	PRIMARY TREATMENT COMPLEX NO. 2	PRIMARY TREATMENT COMPLEX NO. 2 PRIMARY BASIN NO. 4 SCUM PIT LEVEL INDICATING TRANSMITTER	0	17	FT	[TD-I-004]	[PTC2-E-024] [PTC2-E-026] [PTC2-E-028]	[PTC2-I-008]	[PTC2-I-001]	
FEC1-PIT-4111 OP-PIC-4111	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SCUM PUMP NO. 1 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC1-E-007]	[PTC1-I-007]	[PTC1-I-001]	
FEC1-PIT-4121 OP-PIC-4121	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 1 & 2	PRIMARY TREATMENT COMPLEX NO. 1 SCUM PUMP NO. 2 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC1-E-007]	[PTC1-I-007]	[PTC1-I-001]	
FEC2-PIT-4131 FEC2-PIC-4131	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SCUMP PUMP NO. 1 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC2-E-026] [PTC2-E-028]	[PTC2-I-008]	[PTC2-I-001]	

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FEC2-PIT-4141 FEC2-PIC-4141	P125 N/A	17380 17200	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 SCUMP PUMP NO. 2 DISCHARGE PRESSURE INDICATING TRANSMITTER	0	150	PSI	[TD-I-003]	[PTC2-E-026] [PTC2-E-028]	[PTC2-I-008]	[PTC2-I-001]	
FEC2-TIT-4201	T103	17380	FLOW EQUALIZATION BASIN NO. 3 & 4	PRIMARY TREATMENT COMPLEX NO. 2 ELECTRICAL ROOM AMBIENT AIR TEMPERATURE INDICATING TRANSMITTER	32	122	DEG F	[TD-I-001]	[PTC2-E-034]	[PTC2-I-012]	[PTC2-I-003]	
OP-LIT-4202 OP-LE-4202	L718	17380	OPERATIONS BUILDING	OPERATIONS BUILDING EXCESS FLOW WET WELL INDICATING TRANSMITTER	0	?	FT	[TD-I-004]	[OP-E-059]	[OP-I-014]	[OP-I-003]	
FEC1-LIT-4210 FEC1-LE-4210	L718	17380	FLOW EQUALIZATION BASIN NO. 1 & 2	FLOW EQUALIZATION BASIN NO. 1 LEVEL INDICATING TRANSMITTER	0	20	FT	[TD-I-004]	[PTC1-E-006] [PTC1-E-010]	[PTC1-I-011]	[OP-I-001]	
FEC1-LIT-4211	P104	17380	FLOW EQUALIZATION BASIN NO. 1 & 2	FLOW EQUALIZATION BASIN NO. 1 LEVEL INDICATING TRANSMITTER	0	20	FT	N/A	[OP-E-062]	[PTC1-I-011]	[OP-I-001]	
FEC1-LIT-4220 FEC1-LE-4220	L718	17380	FLOW EQUALIZATION BASIN NO. 1 & 2	FLOW EQUALIZATION BASIN NO. 2 LEVEL INDICATING TRANSMITTER	0	20	FT	[TD-I-004]	[PTC1-E-006] [PTC1-E-010]	[PTC1-I-011]	[OP-I-001]	
FEC1-LIT-4221	P104	17380	FLOW EQUALIZATION BASIN NO. 1 & 2	FLOW EQUALIZATION BASIN NO. 2 LEVEL INDICATING TRANSMITTER	0	20	FT	N/A	[OP-E-062]	[PTC1-I-011]	[OP-I-001]	
FEC2-LIT-4230 FEC2-LE-4230	L718	17380	FLOW EQUALIZATION BASIN NO. 3 & 4	FLOW EQUALIZATION BASIN NO. 3 LEVEL INDICATING TRANSMITTER	0	20	FT	[TD-I-004]	[PTC2-E-023] [PTC2-E-027]	[PTC2-I-011]	[OP-I-001]	
FEC2-LIT-4231 FEC2-LE-4231	L718	17380	FLOW EQUALIZATION BASIN NO. 3 & 4	FLOW EQUALIZATION BASIN NO. 3 LEVEL INDICATING TRANSMITTER	0	20	FT	[TD-I-004]	[PTC2-E-023] [PTC2-E-027]	[PTC2-I-011]	[OP-I-001]	
FEC2-LIT-4240	L718	17380	FLOW EQUALIZATION BASIN NO. 3 & 4	FLOW EQUALIZATION BASIN NO. 4 LEVEL INDICATING TRANSMITTER	0	20	FT	[TD-I-004]	[PTC2-E-023] [PTC2-E-027]	[PTC2-I-011]	[OP-I-001]	
FEC2-LIT-4241 FEC2-LE-4241	L718	17380	FLOW EQUALIZATION BASIN NO. 3 & 4	FLOW EQUALIZATION BASIN NO. 4 LEVEL INDICATING TRANSMITTER	0	20	FT	[TD-I-004]	[PTC2-E-023] [PTC2-E-027]	[PTC2-I-011]	[OP-I-001]	

SECTION 17502

ANALYZERS – SUSPENDED SOLID

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Provide and test analyzer for continuous monitoring and measurement of suspended solids in primary sludge piping.

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 REFERENCES

A. Refer to Section 17100.

1.04 – 1.05 (NOT USED)

1.06 SUBMITTALS

A. Furnish submittals in accordance with Sections 01300 and 17100.

1.07 QUALITY ASSURANCE

A. Refer to Section 17100.

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.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17100.

1.09 PROJECT CONDITIONS

A. Refer to Section 17100.

1.10 WARRANTY

A. Refer to Section 17100.

1.11 MAINTENANCE

A. Refer to Section 17100.

B. Furnish all parts, materials, fluids, etc., necessary for maintenance and calibration purposes for one year:

1. Deliver all supplies before substantial completion.

C. Furnish the following spare parts:

1. As recommended by the manufacturer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Suspended Solid Analyzer: Turbidity and Suspended Solids probe inline installation in sludge line.

1. HACH Model TSS W sc TriClamp

2. Endress + Hauser Turbimax CUS51D sensor with retractable ball valve

2.02 MANUFACTURED UNITS

A. Identification:

Tag No.	Location
FEC1-AIT-3802	PTC1 Sludge Pipe Gallery
FEC1-AIT-3812	FEC1-SLP-001 Discharge
FEC1-AIT-3822	FEC1-SLP-002 Discharge
FEC1-AIT-3832	FEC1-SLP-003 Discharge
FEC2-AIT-3902	PTC2 Sludge Pipe Gallery
FEC2-AIT-3912	FEC2-SLP-001 Discharge
FEC2-AIT-3922	FEC2-SLP-002 Discharge
FEC2-AIT-3932	FEC2-SLP-003 Discharge

B. General:

1. The suspended solid sensors will be installed on 8-inch ductile iron pipe, on the discharge side of sludge pumps and on the 12-inch ductile iron pipe main discharge header in each treatment complex. The sensor will be installed on vertical or horizontal runs of pipe depending on location, reference PLANs for additional details about location. Pressure on pump discharge side can be as high as 120 PSI. Provide sensors capable of working within the expected pressure ranges.

2. The method of measuring suspended solids will be with combined multiple beam alternating light method with IR diode system and beam focusing.

3. Suspended solids measurements use additional 120° scattered light measurement with a wavelength of 860 nm.

C. Performance Requirements:

1. Other methods of turbidity and suspended solids measurement, such as surface scatter methods, are not acceptable.

2. 8-channel multiple angle measurements to be provided to achieve a more precise data.

2. Measurement range

a. Solids: 0.01-50 g/L, With SiO standard solution; depending on sludge characteristics

3. Accuracy

a. TSS: < 5% of measured value or +/- 0.01 g/L, whichever is greater

4. Repeatability

a. TSS content: < 4 %

5. Detection limit

a. Suspended solids: 0.01 g/L

6. Response time: 1 s < T90 < 300 s (adjustable)

7. Signal Averaging Time: User selectable ranging from 1 to 300 seconds

8. Units of measure:

a. Suspended Solids: User Selectable g/L, mg/L, ppm, or % solids

D. Indicating Transmitter:

1. Mounting: Remote from sensor.

2. Output Signal: 4-20 mA

3. Power: 120 VAC

4. Local Indicator: LCD outdoor UV rated indicator screen

5. Interface: Buttons on face of transmitter for instrument configuration and menu navigation

6. Manufactured by Hach, model sc200 transmitter with a digital display screen or Engineer approved equal.

2.03 SHOP TESTING:

A. Calibrate the sensors for solid matter measurement. Provide certificate of calibration for all units.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Refer to Section 17100.

B. Install the analyzer in accordance with the manufacturer's instructions and recommendation.

C. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 17100.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:

1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. Refer to Section 17100.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 17100.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

C. Furnish 8 hours of OWNER training in two 4-hour sessions for operator and management teams.

3.06 PROTECTION

A. Refer to Section 17100.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:

1. Instruments may be shown on the Drawings, in the Specifications or both.

3.08 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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 17511

ELECTROMAGNETIC FLOW METERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Inline type electromagnetic elements and transmitters for measurement of flow rates of liquid water.

B. Furnish and install the flowmeters specified in the quantities shown below in Section 2.02.

1.02 RELATED REQUIREMENTS

A. PLANS show general arrangement, location, connection type and basic dimensions.

B. Related work as called for on PLANS or specified elsewhere in this or other TECHNICAL SPECIFICATION Sections.

1.03 - 1.05 (NOT USED)

1.06 SUBMITTALS

A. Furnish submittals in accordance with Sections 01300 and 17100.

B. Test Reports:
   1. 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.

C. Operating Manuals:
   1. 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.
   2. Complete installation, calibration, and testing manuals.

1.07 QUALITY ASSURANCE

A. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

B. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 – 1.11 (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Shall be one of the following or approved equal:

1. Inline type:
    a. Endress + Hauser Promag 400 series,
    Krohne,
    Foxboro,
    or approved equal.

B. Furnish each primary element and Flow Indicating Transmitter specified herein by a single manufacturer.

2.02 PRODUCTS

A. Reference PLANS for flow meter size and quantity.

B. Electromagnetic Flow Meter and Transmitter, Inline-type:
1. General:
    a. Function: Measure flow rate of clean, potable, raw or other debris-free water applications.
    b. Type: Inline type electromagnetic flow sensing element, flow meters shall utilize the characterized field principle of electromagnetic induction, and shall produce DC signals directly proportional to the liquid flow rate.
    c. Meters shall be capable of bidirectional flow and totalize for forward, reverse and net totals.
    d. Parts: electromagnetic flow sensor, transmitter, interconnecting cable.
2. Service:
    a. Process Fluid: Filtered water or non-potable water.
    b. Pipe Material: DI.
    c. Pipe Size: As noted.
3. Performance:
    a. Process Flow Range: As noted.
    b. Process Temperature (F): -22 to 149
    c. Minimum Conductivity: 5 uS/cm for fluids generally
    d. Accuracy:
        1) ±0.25% of reading from 1 to +30 feet per second, reverse flow indication.
        2) Repeatability: 0.1 percent of range.
        3) Minimum turndown shall be 100:1.
4. Flow Tube:
    a. Each meter shall be furnished with a stainless steel metering tube and carbon steel flanges with a PTFE liner. Linerless designs are not acceptable. Liner shall have a minimum thickness of 0.125 inches. The inside diameter of the liner shall be within 0.125 inches of the inside diameter of the adjoining pipe. Liner protectors shall be provided on all flow tubes.
    b. Each flow tube shall be factory calibrated in an ISO 9001 and NIST certified facility and assigned a calibration constant or factor to be entered into the associated transmitter as part of the meter configuration parameters. Manual calibration of the flow meter shall not be required. Meter configuration parameters shall be stored in non-volatile memory in the transmitter. An output hold feature shall be provided to maintain a constant output during configuration changes.
    c. The flow tube shall be provided with Nickel Alloy (Hastelloy C) or 316 SS flush mounted electrodes. Ultrasonic electrode cleaning shall not be acceptable.
    d. Flow tube shall be rated for pressures up to 1.1 times the flange rating of adjacent piping. Meter and transmitter housings shall meet NEMA 4X requirements as a minimum. When mounted in a meter vault (or otherwise specified), flowtube shall be of IP 68 construction as installed by the factory (no field IP 68 installation allowed). When meter and transmitter are located in classified explosion hazard areas, the meter

and transmitter housings shall be selected with rating to meet the requirements for use in those areas. Non-metallic transmitter housings shall not be acceptable.

e. Flow tubes shall be 150-lb flange mounted unless otherwise noted. The cables for interconnecting the meter and transmitter shall be furnished by the manufacturer.

f. Grounding rings shall be provided for all meters. The use of grounding electrodes are not acceptable.

g. All materials of construction for metallic wetted parts (electrodes, grounding rings, etc.) shall be minimum 316 stainless steel, but shall be compatible with the process fluid for each meter in accordance with the recommendations of the manufacturer.

5. Transmitter:

a. Magnetic flow meter systems shall include a magnetic flow tube and a microprocessor-based "smart" transmitter that is capable of converting and transmitting a signal from the flow tube.

b. Maximum response time shall be adjustable between 1 and 100 seconds as a minimum.

c. Transmitter ambient temperature operating limits shall be -10 to +50 degree C.

d. The transmitter shall be remote mounted and have a polyurethane painted dual compartment aluminum, Nema 4X housing. The transmitter shall utilize a 90-220 VAC power supply and have outputs including 4-20 mA (Hart), scalable frequency (0-10,000 Hz, pulse output, two (2) discrete outputs (to 30 VDC) and one (1) discrete input.

e. The transmitter shall provide a pulsed DC coil drive current to the flow tube and shall convert the returning signal to a linear, isolated 4-20 mA DC signal. The transmitter shall utilize "smart" electronics and shall contain automatic, continuous zero correction, signal processing routines for noise rejection, and an integral LCD readout capable of displaying flow rate and totalized flow. The transmitter shall continuously run self-diagnostic routines and report errors via English language messages. Standard diagnostics shall include transmitter hardware and software fault, flowtube sensor coil fault, tunable empty pipe, grounding and wiring fault and high process noise.

f. The transmitter's preamplifier input impedance shall be a minimum of 109-1011 ohms which shall make the system suited for the amplification of low-level input signals and capable of operation with a material build up on the electrodes.

g. The transmitter shall provide an automatic low flow cutoff below a user configurable low flow condition (0-10%). The transmitter's outputs shall also be capable of being forced to zero by an external contact operation.

h. The transmitter shall be capable of communicating digitally with a remote configuration device via a frequency-shift-keyed, high frequency signal (Hart) superimposed on the 4-20 mA output signal. The remote configuration device shall be capable of being placed anywhere in the 4-20 mA output loop. A security lockout feature shall be provided to prevent unauthorized modification of configuration parameters.

2.03 SOURCE QUALITY CONTROL

A. Factory calibrate all instruments and/or representative instruments at a facility that is traceable to the National Institute of Standards and Technology (NIST):

1. Provide completion documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 INSTALLATION

A. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. Perform installation in accordance with Manufacturer's requirements and recommendations to ensure proper centering and seating of orifice plates.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04-3.05 (NOT USED)

3.06 PROTECTION

A. Store flowmeter elements in factory containers in a secure, protected location prior to installation.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be shown on the Drawings, in the Specifications or both.

3.08 – 3.10 (NOT USED)

3.11 MEASUREMENT AND PAYMENT

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

SECTION 17600

DISTRIBUTED CONTROL SYSTEM

PART 1 GENERAL

1.01 SUMMARY

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 ICS shall be responsible for furnishing and installing the Communication System for the Distributed Control System “DCS” shown on the PLANS, and as specified hereinafter.

D. The ICS shall be responsible for all modifications to the Owner’s existing distributed control system as also shown on the PLANS.

E. The subsequent document entitled “Section 17600 Appendix A – Walnut Creek WWTP Pumping System 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 related contract requirements. Refer to the PLANS and 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 as well as Modbus Plus network
      d. Interface with Power Monitoring Units, Protective Relays, and other devices as shown on the PLANS.
      e. Interface with process/mechanical equipment having packaged control systems 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 and Ethernet System Copper Cable Testing Submittal: Provide a complete set of cable test results for the testing required under subsection 3.02 “Fiber-Optic System and Ethernet System Copper Cable – 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. PLC I/O “Host Pack Template” Spreadsheets:
   1. The Owner has standard Excel spreadsheet templates, termed the “Host Pack Template” of enumerating information about the I/O points for the installation of the system. Upon completion of the system installation and PAT, the Owner shall supply to the ICS the Host Pack Template in Excel format for the contractor to complete.
   2. The Contractor is to complete and submit in Excel format the Owner provided Host Pack Template.

F. 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.

G. Training Submittals: Submit not less than 4 weeks prior to the time that the associated training is to be provided. Submit per Section 17100.

H. Additional submittals as required by Specifications Section 17100, Section 01300 and Section 01730 of the Contract Specifications.

I. Refer to the requirements of Specifications Section 17100.

J. Configuration System Submittal per subsection 2.09, this Section of the Specifications.

1.05 SPARE PARTS

A. Provide the following spare parts at minimum:
   1. Provide the following SPARE equipment, complete with all accessories:
      a. PLC processor units (CPU Modules): Two (2) of each type used
      b. PLC power supply units: Ten Percent (minimum of 2) of the number required for each type of PLC used
      c. PLC RIO Head module: Ten Percent (minimum of 2) of the number required for each type of PLC used
      d. PLC RIO Drop Module: Ten Percent (minimum of 2) of the number required for each type of PLC used
      e. PLC I/O Module (AI, AO, DI, DO): Ten Percent (minimum of 2) of the number of each type used.
      f. PLC rack: One (1) of each type used.
      g. Local Area Network (LAN) system component (converter, modem, transceiver, etc.): Ten percent (minimum of 2) of each type provided
      h. Ethernet NOE module: Ten Percent (minimum of 2) of the number required for each type of PLC used.
      i. One (1) ethernet switch complete will all modules for each type used
      j. One (1) spare Type 1 OIU complete with all accessories.
      k. 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 “Instrumentation and Control Cabinets and Associated Equipment”, 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 PLCs I/O racks, power supplies, central processing units, patch panels, ethernet switches, computers, etc. All cables shall be tagged per Section 17200 "Instrumentation and Control Cabinets and Associated Equipment".
7. All equipment cabling, including copper Ethernet cable, all patch cords, etc., shall be tagged according to the guidelines and tagging labeling system outlined in Section 17200 "Instrumentation and Control Cabinets and Associated Equipment", 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*(Al*A2*A3 ... *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
         2) Minimum operating distance: 10,000 feet
         3) Rate: 10/100 Mbps.

c. The remote I/O shall be single channel, Ethernet, in a ring network topology. All remote I/O cabling and installation shall be in accordance to the Modicon M580 System Planning Guide.
d. 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)).
e. 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.
f. Modbus and Modbus Plus shall be in accordance to the Square D standard for cable pin out and cable type, as well as the end devices to be interconnected. The cables shall be shielded. Refer to the Square D Modicon Hardware Reference Guide for Modbus serial cable pin out and guidelines. Furnish and install ruggedized taps and terminators were available from the manufacturer.

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: MODICON M580 Automation Series model number BMX CPS 3500, No Equal.
b. Accessories: Provide screw clamp type removable terminal blocks, Modicon M580 model number BMX XTS CPS10 No Equal.
3. Central Processor:
a. Memory: 65535 Kbytes, at minimum
b. Ports: 1 mini B Universal Serial Bus (USB) port, 1 Ethernet service port, and 2 Ethernet Modbus TCP/IP port
c. Accessories: Provide a 4 GB SD Memory Card, as manufactured by the CPU manufacturer.
d. Manufacturer: Schneider Electric MODICON M580 BME P58 4040, No Equal.
4. Discrete Input Module DI:
a. Manufacturer: MODICON M580 Automation Series Model number BMX DAI 1604 No Equal.
5. Discrete Output DO:
a. Manufacturer: MODICON M580 Automation Series model number BMX DRA 0805 No Equal.
6. Analog Input Module AI:
a. Manufacturer: MODICON M580 Automation Series model number BMX AMI 0810 No Equal. With each module, furnish and install cage clamp terminal block Modicon Model BMXFTB2800, No Equal.
7. Analog Output Modules AOs:
a. Manufacturer: MODICON M580 Automation Series model number BMX AMO 0410 No Equal
8. Network Option Ethernet (NOE):

a. Manufacturer: Modicon M580 Automation Series model number BME NOC 0311 Module, No Equal.

9. PLC Racks
   a. X bus and Ethernet Bus interface. Manufacturer: MODICON M580 Automation Series model number BME XBP 1200 No Equal
10. PLC Rack Extender Module:
    a. Accessories:
       1) Provide X bus extender cord, length as required per PLANS, manufactured by Extender Module manufacturer, model number BMX XBC series No Equal.
       2) Provide line terminator for extender module located at each end of the daisy chain, manufactured by the Extender Module manufacturer, model number TSXTLYEX, No Equal.
    b. Manufacturer: MODICON M580 Automation Series model number BMX XBE 1000 No Equal
11. Remote I/O Drop Module:
    a. Manufacturer: MODICON M580 Automation Series model number BME CRA 31210 No Equal.
12. Accessories:
    a. Unless specified otherwise, provide 20-way screw clamp type removable terminal block with each module, Modicon Model BMXFTB2010, 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 Module 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 0810 No Equal
7. Analog Output Module AO
   a. Manufacturer: MODICON M340 Automation Series model number BMX AMO 0410 No Equal

8. Network Option Ethernet (NOE)
    a. Manufacturer: Modicon M340 Automation Series model number BMX NOE 0100 Module, No Equal
9. PLC Racks:
    a. Manufacturer: MODICON M340 Automation Series model number BMX XBP 1200 No Equal
10. 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
11. Accessories:
    a. Provide 20-way screw clamp type removable terminal block with each module, Modicon Model BMXFTB2010, no equal.

2.03 LAPTOP PROGRAMMING COMPUTER

A. Mother Board
1. A minimum of Intel Intel Core i7-7820HQ (Quad Core 2.90GHz, 3.90GHz Turbo, 8MB 45W, w/Intel HD Graphics 630)
2. 16GB, DDR4-2400MHz SDRAM, 1 DIMMS

B. Hard Drive (HDD)
1. Minimum 500GB Solid State Hard Drive.
2. The hard drive shall be partitioned with the NTFS file system type

C. Pointing Device and Keyboard
1. Keyboard
    a. Anti-microbial keyboard with number pad and backlight feature
2. The laptop shall consist of integrated dual pointing device
    a. Touchpad pointer and stick pointer
    b. Multi-touch touchpad with three buttons

D. Graphics Display
1. The integrated laptop display type shall be 15.6" UltraSharp FHD(1920x1080) Wide View Anti-Glare LED-backlit, non-touch

E. Peripheral Ports
1. 1 x SD Card Reader (SD, SDHC, SDXC, supporting up to 2TB);
2. 1 x Thunderbolt ® 3
3. 4 x USB3.0 with PowerShare;
4. 1 x mDP 1.4;
5. 1 x HDMI 1.4;
6. 1 x Headphone and microphone combo jack;
7. 1 x SmartCard Reader

F. Video
1. Minimum of Nvidia Quadro M1200 w/4GB GDDR5
2. The Computer shall have a special function key that enables the video card signal to be sent to the Laptop’s LCD display, the HDMI output port, or both

G. Audio
   1. The laptop shall consist of a minimum of Stereo: 20-bit stereo-digital to analog and 18-bit stereo analog to digital 16 bit integrated audio card
   2. Dual integrated high quality speakers

H. Communication
   1. The laptop shall at minimum have the following communication devices
      a. Intel WiFi Link 8265 Card (802.11ac + Bluetooth 4.2), 2x2
      b. Integrated 10/100/1000 BASE-TX Gigabit Ethernet communication with RJ-45 port interface
   2. All communication drivers for each communication device shall be installed on the laptop.

I. Battery
   1. The Laptop battery shall be user accessible and replaceable
   2. Minimum 91Whr long life cycle Ion Polymer battery
   3. The laptop is to have a charging unit to fully charge the battery while providing full power to the laptop.
   4. The charging means shall also be a means of providing power to the laptop in the event that the battery is fully discharged.

J. Software
   1. Each software installed on the laptop shall be legally licensed to the owner.
   2. Operating System
      a. Microsoft Windows® 10 Professional, 64-bit, with service packs and media
   3. Drivers and Laptop Maintenance utilities
      a. All drivers and Laptop maintenance and diagnostic utilities including battery percent charged, estimate of laptop remaining operation time when powered only by the battery source, shall be Windows 10 Professional compatible.
      b. Drivers for the following shall be installed on Windows 10 Professional system are:
         1) Network Communications
         2) Audio card
         3) Video card
         4) Battery time of operation estimation and battery percent charged
         5) Laptop suspend (sleep) mode
   4. Provide the media (DVD-ROM or USB) and installation guide for all software, including the operating system and all media for complete system recovery to the Laptop system state as initially provided out of the package by the Laptop manufacturer.

K. USB Flash Drives
   1. Provide two (2) 128 gigabyte USB 3.0 removable Flash Drive Units.

L. Backpack Case
   1. Provide Nylon Deluxe back pack case sufficiently large to house the Laptop unit
   2. The case should have additional pouches/pockets for storage of cables, CD-R disks, etc.

M. The Laptop shall include a five (5) year manufacturer's warranty covering parts and labor and next business day on site support as well as ProSupport and 3 Year CompleteCare Accidental Damage Protection

N. The Laptop shall be manufactured by Dell and shall be the most current version of the Dell model Precision Workstation series laptops.

O. Each laptop shall have a USB-C type port with Thunderbolt version 3 or later for interconnection to docking station. The Laptop ports for docking station shall be configured for direct interconnection with the Dual USB-C Thunderbolt docking cable without any modification to the docking station's manufacturer's docking cable connectors.

P. For each Laptop, furnish docking station to be connected to laptop with the included docking cable. Docking station shall be manufactured by the same manufacturer as Laptop manufacturer. At minimum, the docking station shall have the following features:
   1. Docking Cable: Docking cable shall interconnect docking station to Laptop. The docking cable shall have interface with Dual USB-C Thunderbolt Dock for interconnection to Laptop without any modification to cable connectors. Furnish one docking cable per docking station.
   2. Support a Minimum of three (3) displays at full HD (1920 x 1080 p) each.
   3. Minimum 210W AC adapter, rated for 120VAC, 60Hz. primary power.
   4. The docking station shall, at minimum, have the following ports
      a. Minimum 2 x USB 2.0 - 4 pin USB Type A
      b. Minimum 2 x USB 3.0 - 9 pin USB Type A
      c. Minimum 1 x display / video - HDMI - 19 pin HDMI Type A
      d. Minimum 1 x display / video - DisplayPort - 20 pin DisplayPort
      e. Minimum 1 x display / video - Mini DisplayPort
      f. Minimum 1 x network - Ethernet 1000 - RJ-45
      g. Minimum 1 x headset - output - mini-phone 3.5 mm
      h. Minimum 1 x audio - output - mini-phone 3.5 mm
      i. Minimum 1 x video - VGA - 15 pin D-Sub (DB-15)
      j. Minimum 1 x Thunderbolt 3 - Thunderbolt - 24 pin USB-C port.

2.04 TYPE 1 OPERATOR INTERFACE UNIT

A. General: The OIU shall effectively be a Graphical front end to the local PLC network and have complete read/write access to all registers of the local PLC network to which the OIU is connected.
   1. Communication:
      a. The OIU shall utilize Ethernet communication protocols to communicate to other peripheral devices, including PLC's, as shown in the contract drawings.
      b. The ICS shall provide the necessary cabling for communicating with the OIU for programming and configuration purposes with a personal computer. The program cabling shall be USB and minimum of 12 feet in length.
      c. The ICS shall install the necessary cabling, connectors, and termination for communication between the OIU Ethernet interface and the Ethernet network.
   2. Software:

a. Operating System: Magelis Operating system, with latest service Pack, preinstalled by the OIU manufacturer.
b. Software: Vijeo Designer run time software, preinstalled by the OIU manufacturer.
c. All additional necessary software, software drivers, etc. complete will all licenses, as necessary for the proper operation of the OIU.

3. Mounting:
   a. Mount in control panel door as shown on the Drawings. All communication ports shall be accessible with OIU installed in the control panel.
   b. Provide mounting hardware as required and install OIU according to manufacturer's instructions and requirements. Provide trim accessories to seal the gap between the OIU and control panel door.
4. Accessories:
   a. 1 Gigabyte secure digital (SD) card, manufactured by the OIU manufacturer.
   b. All necessary cables, connectors, and terminators. Minimum cable length shall be 12 feet

B. Display Module:
1. Type: Flat Color Active Matrix (TFT) LCD display type, with touch screen capability
2. Size: 15" diagonal
3. Minimum Resolution: 1024 x 768 pixels,
4. Colors: 16,000,000 colors
5. Power Input: 24 volts DC.
6. Communication Ports:
   a. One (1) USB 2.0 Type A port,
   b. One (1) USB 2.0 Mini-B port
7. Physical Environment:
   a. Ambient Air Temperature: +32° to +140° Fahrenheit
   b. Ambient Air Humidity: 10% to 90% Relative Humidity Non-condensing
   c. Free of corrosive gases
8. Cooling Method: Natural air circulation
9. Enclosure: NEMA 4X rated
10. Manufacturer: Schneider Electric Magelis GTU HMIDT732, No Equal.

C. Box Module:
1. Power Input: 24 volts DC.
2. Memory:
   a. System Card: SD Card 1 GB
   b. Internal Memory: 256 MB RAM
   c. Backup Memory: 512 kB NVRAM
3. Communication Ports:
   a. Two (2) RJ-45 Ethernet ports,
   b. Two (2) USB 2.0 Type A ports,
   c. One (1) USB 2.0 Mini-B port,
   d. One (1) RJ-45 RS-485 serial port,
   e. One (1) 9 pin RS-232/422/485 serial port,
   f. Two (2) SD card slots [one (1) system and one (1) storage]
4. Communication Protocol: Ethernet, Modbus TCP/IP

5. Output Interface:
    a. One (1) 300 mW speaker output,
    b. One (1) 24 VDC auxiliary alarm output
6. Physical Environment:
    a. Ambient Air Temperature: +32° to +140° Fahrenheit
    b. Ambient Air Humidity: 10% to 90% Relative Humidity Non-condensing
    c. Free of corrosive gases
7. Cooling Method: Natural air circulation
8. Manufacturer: Schneider Electric Magelis GTU HMIG3U, No Equal.

2.05 TYPE 2 OPERATOR INTERFACE UNIT

A. General: The OIU shall effectively be a Graphical front end to the SCADA network and have complete read/write access to all registers of the plant SCADA network to which the computer is connected.

B. Display screen:
1. Type: Flat Color Active Matrix (TFT) LED display type, with touch screen capability
2. Size: 19” diagonal
3. Minimum Resolution: 1280 x 1024 pixels
4. Colors: 32 bit color
5. Accessories:
    a. Pop up window for numeric keypad and alphanumeric keypad displays
    b. Touch sensitive protective film harsh environment coating

C. Hardware:
1. Communication Ports:
    a. Two (2) RS-232 ports
    b. Four (4) USB 3.0 ports
    c. Three (3) 10/100/1000 Base Tx Ethernet port. Ports may be obtained by use of Ethernet module installed in PCI slot
2. Enclosure: Stainless steel, NEMA 4 rated
3. Power Input: 24 volts DC
4. Hard Drive: Minimum of 256 GB solid state disk
5. Processor: Intel i7 processor with minimum 3 GHz clock speed
6. Memory: 8 GB RAM, at minimum.

D. Communication:
1. The OIU shall utilize Ethernet communication protocols to communicate to other peripheral devices, including PLC’s, as shown in the contract drawings.
2. The ICS shall install the necessary cabling, connectors, and termination for communication between the OIU Ethernet interface and the Ethernet network.

E. Software:
1. Operating System: Windows 10 Professional, 64 bit Operating system, with latest service Pack, preinstalled by the OIU manufacturer.
2. Latest version of GE Proficy IFix SCADA unlimited tag runtime license, key, and software media. Furnish for installation by the Owner.
3. All additional necessary software, software drivers, etc. complete with all licenses, as necessary for the proper operation of the OIU.

F. Keyboard:
   1. Sealed to Nema 4X standards, heavy duty industrial type keyboard suitable for harsh environment.
   2. 113-key functionality (includes a separate numeric keypad and 20 function keys) Integrated Button Pointer.
   3. Key Material - Industrial silicone rubber
   4. Key Travel: 0.098", 0.45 lb. nominal actuation force, 10 million cycle life
   5. Three year warranty
   6. Full-Travel Wall Mount Keyboard with Button Pointer Model KB-R2-WMT-BLK-4-USB as manufactured by Hope Industrial.
   7. Mount Keyboard on front of panel door below OIU using keyboard vendor provided mounting hardware and template. Mount keyboard such that the typing surface of the keyboard is 38” above finished floor (floor on which user is standing to face OIU), inclusive of housekeeping concrete pad height. Mount keyboard such that it is horizontally centered on the door.

G. Mounting:
   1. VESA mount OIU on face of control panel at door shown on the Drawings. All communication ports shall be accessible with OIU installed on the control panel.
   2. Provide mounting brackets and hardware as required and install OIU and all accessories according to manufacturer’s instructions and requirements.

H. Accessories:
   1. All necessary cables, connectors, and terminators. Minimum cable length shall be 12 feet
   2. VESA mount Fixed Low-Profile Flat-Panel Mount bracket. Coordinate bracket with OIU mounting requirements. Bracket shall be model PRF as manufactured by Premier Mount, or approved equal.
   3. Keyboard Bracket.
   4. Panel mountable, gasketed, Nema 4X rated split cable gland kit for all cables connecting to OIU through control panel door. Split cable gland kit shall be as manufactured by Icotek Kel-ER, or approved equal.
   5. Nema 4X gasketed cable grommets for final cable connection to OIU per the OIU manufacturer’s recommendations.
   6. Accessories specific to “FEC2-OIU-002” as shown on the PLANS:
      a. In addition to the requirements specified in Subsection 2.05, this Section of the Specifications, furnish “FEC2-OIU-002” complete with the following accessories:
         1) Full-Travel Benchtop Keyboard with Button Pointer Model KB-R2-WMT-BLK-4-USB as manufactured by Hope Industrial.
         2) Table Stand for the S19, as manufactured by Noax Technologies.

I. Manufacturer: Noax Technologies Steel Series S19 complete with specified accessories, No Equal.

2.06 ETHERNET CONVERTER

A. Modbus TCP/IP to RS-485 Converter: Where shown on the PLANS, furnish and install Modbus TCP/IP to RS-485 converter. The converter shall convert between Modbus TCP/IP Ethernet protocol and Modbus RTU serial RS-485 protocol. The converter shall be as follows:

1. 24VDC power input rating.
2. DIN Rail mountable
3. Ports:
    a. One (1) RJ45 10/100Base-TX copper port.
    b. One (1) RJ-45 port for serial configuration of converter
    c. RS-485 connector terminal strip, 4-wire capable
4. Operating temperature range: -25°C to 70°C
5. The Media Converter shall have DIP switches for setting serial connection Bias, Termination, and 2-wire / 4-wire jumper
6. Furnish the following accessories:
    a. RS232 serial to Ethernet port configuration kit model (TCSEAK0100) as manufactured by Schneider Electric
7. The Modbus TCP/IP to RS-485 Converter shall be the PowerLogic EGX100 as manufactured by Schneider Electric.

2.07 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. It is anticipated that Ethernet Switch technology will advance over time and the latest model of Ethernet switch having the features specified hereinafter as a minimum shall be furnished and installed.
2. All switches shall be provided with the latest firmware from the manufacturer, where applicable. Switches to be stacked must be supplied with the same feature set, IP LAN, IOS, etc.
3. All switches shall be supplied with the manufacturer's support contract for the duration of two years starting from final completion of the project. At minimum switches manufactured by Cisco shall have the Cisco SMART NET for a minimum of two (2) years starting from final completion of the project and registered in the name of the Owner.
4. SFP Module: Each SFP module shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector. All SFP modules shall be as manufactured by Cisco.
5. Should the specified switch be designated as "End of Life" and/or discontinued by its manufacturer, contractor shall furnish and install an alternate switch, whose specifications meet or exceed the specified switch, by the same manufacturer and that is not designated as "End of Life" and/or discontinued by the switch manufacturer.

B. Type 1 Ethernet Switches:
1. Power Input: 120 volts A.C., 60 Hz
2. Port Quantity and Type: 24 10/100/1000BaseTx ports, 4 of which are dual purpose ports which the user may elect to use as a 10/100/10000Base TX port or as a socket for an SFP module. Note: The previously specified quantity of ports shall be provided even if the PLANS show lesser quantity of ports.
3. Module: Provide minimum four (4) 1000BaseLX/LH SFP modules with each switch. All SFP modules shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector.

4. 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
5. Manufacturer: Cisco Catalyst WS-C3650-24TS, or approved equal.

C. Type 2 Ethernet Switches:
1. Provide Type 1 Ethernet Switch per Subsection 2.07.B, this Section of the Specifications, with the exception that only two SFP modules are required.

D. Type 3 Ethernet Switches:
1. Provide Type 1 Ethernet Switch per Subsection 2.07.B, this Section of the Specifications, with the exception that the four SFP modules are not required.

E. Type 4 Ethernet Switches:
1. Power Input: 120 volts A.C., 60 Hz.
2. Port Quantity and Type: minimum 24 10/100/1000Base TX ports, 4 of which are dual purpose ports which the user may elect to use as a 10/100/10000Base TX port or as a socket for an SFP module.
3. Module: Provide minimum one (1) 1000BaseLX/LH SFP modules with each switch. All SFP modules shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector.
4. Mounting: 19-inch rack mounting with necessary kit. Refer to the PLANS.
5. Accessories:
   a. LAN Base image
   b. For each Ethernet switch, furnish and install 120VAC Ethernet Switch power supply, model PWR-RGD-AC-DC-250 by Cisco.
   c. 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
6. Manufacturer: Cisco Industrial Ethernet Switch IE-4010-4S24P.

F. Type 5 Ethernet Switches:
1. Power Input: 24 volts D.C.
2. Port Quantity and Type: Eight (8) 10/100 BaseTx Ethernet ports
3. Switch shall be the unmanaged type and without power over Ethernet
4. Operating Temperature Range: -40 degrees Celsius to 85 degrees Celsius
5. Accessories: 2 year support contract with the manufacturer, to begin from the time that the system is commissioned and turned over to the Owner.
6. Manufacturer: N-Tron 508TX, or approved equal

G. Type 6 Ethernet Switches:
1. Power Input: 24 volts D.C.
2. Port Quantity and Type: Five (5) 10/100 BaseTx Ethernet ports
3. Switch shall be the unmanaged type and without power over Ethernet
4. Operating Temperature Range: -40 degrees Celsius to 85 degrees Celsius
5. Accessories: 2 year support contract with the manufacturer, to begin from the time that the system is commissioned and turned over to the Owner.
6. Manufacturer: N-Tron 405TX, or approved equal.

H. Type 7 Ethernet Switches:
1. Power Input: 120 volts A.C., 60 Hz

2. Port Quantity and Type: Eight (8) 10/100 BaseTx Ethernet ports and 2 combo ports. Each combo port shall consist of one (1) SFP based Gigabit Ethernet port.
3. Module: Provide minimum two (2) 1000BaseLX/LH SFP modules with each switch. All SFP modules shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector.
4. Enclosure: Sealed, rated NEMA 4X
5. Mounting: 19-inch rack mounting with necessary kit. Refer to the PLANS.
6. Software: LAN Base manufacturing license
7. Accessories:
    a. 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
    b. For each Ethernet switch, furnish and install 19-inch DIN-rail adapter for rack mounting, model STK-RACK-DINRAIL= by Cisco, or approved equal.
    c. For each Ethernet switch, furnish and install 120VAC Ethernet Switch power supply, model PWR-IE170W-PC-AC= by Cisco, or approved equal.
8. Manufacturer: Cisco Industrial Ethernet IE-2000-8TC-G-B, or approved equal.

I. 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

J. Accessories:
1. Furnish and install mounting brackets and hardware as required to install each Ethernet Switch according to manufacturer's instructions and requirements
2. Furnish and install all necessary cables, connectors, and terminators as required for a complete and functional installation

2.08 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. Fiber-Optic Cables:
1. Type: Single-Mode fiber type. Refer to the PLANS.
2. Cable Type: Loose tube fiber-optic cables
    a. Fiber Strand Count: 72 strands
    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. Furnish and install a spider fan-out kit at each end of the cable with the following features:
a. Modular 6 fiber inserts
b. Buffer inserts shall consist of size 1 meter long fan-out buting secured in a composite encasing
c. Fan-out tubing shall consist of Teflon inner tube, an aramid yarn strength member, and an outer protective jacket
d. Kit shall be suitable for use with single-mode cable
e. Manufacturer: Corning “Spider Fan out Kit”, or approved equal.

2. Additional Requirements:
a. Provide a minimum 20.0-foot coil of spare fiber in each manhole throughout the cable length as well as at each patch panel.
b. Terminate fiber optic cable only at the low voltage control panel and motor control center as shown on the PLANS. Do not splice fiber optic cables elsewhere.
c. Terminate all strands of a loose tube fiber optic cable in one, and only one, spider fan out kit.
d. 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) For all loose tube fiber cable, furnish and install SC single mode splice-on connector at each end of the strand. The connector shall be factory pre-polished connector and shall have a factory terminated pre-cleaved fiber strand pigtail that is suitable for machine aligned fusion splicing. The connector shall have a ceramic ultra polish Zirconia ferrule, color coded buffer, cleave protector, splice protection boot, and dust protection cap. Connectors shall be manufactured by "FIS Cheetah Splice-On Connector", or approved equal.
    2) Coordinate type of connector with the device termination.
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 fusion splice-on type connectors, except for those patch cords which are to be preconnectorized by the manufacturer. The connector shall conform to the following. The connector shall conform to the following:
        1) Single-mode insertion loss (typical/maximum): 0.2db/0.3db
        2) Cable Retention: 2.5 pounds.
        3) Type: Factory pre-terminated and pre-polished ceramic ultra-polish zirconia ferrule with fiber stub previously specified.

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 "Instrumentation and Control Cabinets and Associated Equipment", 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 two (2) connector panels
   c. Connector Panels: Two (2) connector panel, with six (6) SC-Duplex single mode adapters of ceramic type per connector panel.
   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-02P, 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 4 connector panels
    c. Connector Panels: Minimum of two (2) 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-02U, or approved equal.
5. Fiber-Optic Patch Cords:
    a. General:
        1) 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
        2) All fiber patch cords shall not consist of any splices of the fiber strands
        3) 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
        4) 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
        5) Each patch cord shall be pre-connectorized with the appropriate type connector by the manufacturer
        6) Provide minimum length of six feet. Provide additional length as required for the application
        7) 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
        8) 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 zerconia ferrule. All single mode connecters 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.
            a) 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

b) 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.

9) 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.
10) Manufacturer: Corning Cable Systems LLC, Model Zipcord cables, or approved equal.

2.09 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 cod 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. Patch panels:
   1. General:
      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 “Instrumentation and Control Cabinets and Associated Equipment”, 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 ¼"

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: Indicate the source of the cable. Use the "patch panel tag"-XX-YY designation where applicable
3) User Side: 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 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 patch panel shall be as follows:
a. Construction: Plastic, fully enclosed type,
b. Quantity of ports: Minimum 2
c. Mounting: Surface mounted. Secure patch panel to backpanel with screws.
d. Manufacturer: "Panduit", Model Mini-Com #CBXJ2IW-A, with "Mini-Com TX6A" UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal.

4. Each Type 3 patch panel shall be as follows:
a. Construction: Plastic, fully enclosed type,
b. Quantity of ports: Minimum 12

c. Mounting: Surface mounted. Secure patch panel to backpanel with screws.
d. Manufacturer: “Panduit”, Model Mini-Com # CBXF12IW-AY, with “Mini-Com TX6A” UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal.

5. Each Type 4 patch panel shall be as follows:
a. Construction: Plastic, fully enclosed type,
b. Quantity of ports: Minimum 4
c. Mounting: Surface mounted. Secure patch panel to backpanel with screws.
d. Manufacturer: “Panduit”, Model Mini-Com #CBXJ4IW-A, with “Mini-Com TX6A” UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal.

D. 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.

E. 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.

2.10 CONFIGURATION SYSTEM

A. Provide a configuration system, including hardware 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.

B. Ship and temporarily install 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, with the exception of PLCs supplied as part of vendor packaged control systems per specification section 13390 "Packaged Control Systems".
   2. All proposed Remote I/O units, including all racks, power supplies, I/O modules, communication modules, remote I/O modules, etc, with the exception of units supplied as part of vendor packaged control systems per specification section 13390 "Packaged Control Systems".
   3. All Communications interface hardware, cabling, and fiber optics electronics for PLC-to-PLC interface, and PLCs to programmer PC interface, OIU interface, etc.
   4. All necessary cabling to interconnect the equipment at the engineer's site as follows:
      a. The programming cabling between the PLC and the Engineer's computer shall, at minimum, consist of four (4) USB programming cables, each of 12 foot length minimum
   5. 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 9700 (Transducer Module) with advanced software option complete with three line LED combination display and keypad Model P40NPLUS. Furnish and install all required cabling to power the units and to interconnect display with EPM unit
   6. With exception to those items in packaged system vendor control panels per specification section 13390 "Packaged Control Systems", provide the following:
      a. Provide all Ethernet Switches
   7. One (1) Type 2 OIU Computer complete with all accessories and software
   8. One (1) laptop complete with all accessories and software
   9. 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".
   10. 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.
   11. When directed by the Engineer, recreate and ship Configuration System from the Engineer's designated facility to Owner's facility.
   12. 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.

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 specification section 17100 and 17600.

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 AND ETHERNET SYSTEM COPPER CABLING- SOURCE QUALITY CONTROL

A. Fiber Optic Splice-on Connector Termination:
   1. The specified splice-on connectors shall be terminated using a fusion splicer and splicing oven with fiber holders to ensure the fiber cables are machine aligned prior to splicing. The splicing oven shall be the Fujikura 12S Fusion Splicer, or approved equal. Splicer and oven shall be compatible with the splice-on connectors. The loss of the fusion splice shall be no greater than 0.1 dB.

B. 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 and tail cords (receiver cables) 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. The results shall also show the individual numerical dB loss values of the loss across each connector, each splice, and each fiber cable.
      i. OTDR traces, legibly plotted The traces shall be displayed on a trend chart with size 7” long and 5” high. The trace shown should be zoomed/scaled so that it spans the area of the displayed chart, and the vertically and horizontal axis labels adjusted accordingly.

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.
   b. Fiber end-to-end attenuation testing
      1) Fiber end-to-end attenuation testing shall be performed on all installed fibers (both used and unused fibers) after connectorization from both ends of the cable.
      2) These tests shall utilize a stabilized light source and optical power meter. The attenuation tests shall be performed at wavelengths of 1310 nm and 1550 nm for Single Mode cable and 850nm and 1300nm for Multi-Mode cable. Documented results to be provided shall include the cables tested, fiber number, direction of tests, wavelength, the power loss (in dB) across the length of fiber cables tested, and reference power reading.
   c. Fiber device-to-device attenuation testing
      1) This testing shall be performed after all necessary patch fiber patch cords have been installed in the system.
      2) This test shall be performed on all renovated fiber optic links between fiber optic devices. The test shall be conducted only after all necessary patch cords to be used in the final system to create the link between devices are properly installed. The tests shall be performed from both ends of the link. The test should include all installed patch cords in the link, including the end patch cords that are to connect to the switches themselves.
      3) These tests shall utilize a stabilized light source and optical power meter as well as OTDR. The attenuation tests shall be performed at wavelengths of 1310 nm and 1550 nm for Single Mode cable and 850nm and 1300nm for Multi-Mode cable. Documented results to be provided shall include the cables tested, fiber number, direction of tests, wavelength, the power loss (in dB) across the length of fiber cables tested, and reference power reading and OTDR results, as identified in these specifications.

C. 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.

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.
      e. Classes shall be designed for students having the equivalent of a one-semester class on personal computers, but no professional programmable controller programming experience, OIU programming experience, or Ethernet switch configuration experience.

B. Additional training program requirements:
   1. Training duration:
      a. Hardware: A minimum of two (2) days, each of eight (8) normal working hours.

b. Software: Provide a minimum of one (1) week, 40 consecutive normal working hours for each of the following:
    1) Modicon Unity Pro XL, for PLC's. Provide at minimum the following courses: Schneider course PLCUTY13 (Unity Pro Programming Level 1), and Schneider course PLCUTY23 (Unity Pro Programming Level 2).

c. Cisco Ethernet switches/routers: Provide a minimum of one (1) week, 40 consecutive normal working hours for ethernet switches/router training. The training shall be performed in Austin, Texas and shall be a private training session exclusively for the personnel designated for this project by the Owner. It should be clarified that this training class is intended for the students to have hands on knowledge to troubleshoot, configure, and maintain the installed Cisco equipment and not necessarily to obtain Cisco certification. Provide training by New Horizons Worldwide, Inc, or Global Knowledge, Inc., course ICND1 or approved equal. For the Ethernet Switch configuration provide, at least, the following training:
    1) How to remotely manage/configure the Ethernet switch/router with an IBM PC compatible computer from:
        a) Serial/USB communication port
        b) terminal telnet session
        c) web browser
    2) How to change the configuration settings of the switch, including its name, IP address, user passwords using commands at the command prompt via serial communication or terminal sessions, as well as graphically from a browser.
    3) Overview of the Ethernet switch hardware provided.
    4) Overview of Ethernet switch configuration settings, as well as guidelines and examples, configured by using commands at the command prompt via serial communication or terminal sessions, as well as graphically from a browser.
    5) Provide emphasis and show actual settings for all configuration settings of the switches used in the plant, in particular those settings relating to setting of VLAN's, VLAN truncking, STP and RSTP setup.
    6) Provide training on Cisco management tools that provide overview, from a web browser, of all the switches in the network, link status, and port status, as well as how to configure such a management tool, and viewing logs of system events, such as network link failures, internal diagnostic failures, modules failures, etc.
    7) Provide training for upgrading the onboard software of an Ethernet switch
    8) Provide training for how to store settings from the switch to a file, as well as how to store settings to a switch from a file.
    9) Provide this training for both command based as well as browser-based configuration via direct connection to the switch (console port) as well as from the switch management tool.
    10) Diagnostic and Troubleshooting: Capabilities, usage, and interpretation of results.

d. 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 one shift, at minimum, with a minimum ten (10) 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

SECTION 17600 APPENDIX A
WALNUT CREEK WWTP PUMPING SYSTEM IMPROVEMENTS
PLC INPUT/OUTPUT SCHEDULE

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"FEC2-PIT-3901" PRELIMINARY TREATMENT COMPLEX NO. 2 SLUDGE DISCHARGE PRESSURE	FEC2-CP-LPU1	FEC2-PLC-100	AI-01	01	
"FEC2-AIT-3902" PTC2 TOTAL SLUDGE DISCHARGE SUSPENDED SOLIDS ANALYZER	FEC2-CP-LPU1	FEC2-PLC-100	AI-01	02	
"FEC2-FIT-3903" PRELIMINARY TREATMENT COMPLEX NO. 2 SLUDGE DISCHARGE FLOW	FEC2-CP-LPU1	FEC2-PLC-100	AI-01	03	
"FEC2-TIT-4201" PRIELECTRICAL ROOM AMBIENT AIR TEMPERATURE	FEC2-CP-LPU1	FEC2-PLC-100	AI-01	04	
"PTC2-AE-1207-02A" HYDROGEN SULFIDE ANALYZING ELEMENT	FEC2-CP-LPU1	FEC2-PLC-100	AI-01	05	
"PTC2-AE-1208-02A" METHANE ANALYZING ELEMENT	FEC2-CP-LPU1	FEC2-PLC-100	AI-01	06	
"FEC2-LIT-4230" FLOW EQUALIZATION BASIN NO. 3 LEVEL	FEC2-CP-LPU1	FEC2-PLC-100	AI-01	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	AI-01	08	
"FEC2-PV-105" VALVE CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	02	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	04	
"FEC2-PV-108" VALVE OPEN STATUS	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	05	
"FEC2-PV-108" VALVE CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	08	
"FEC2-PV-109" VALVE OPEN STATUS	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	09	
"FEC2-PV-109" VALVE CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	11	
"FEC2-FIT-3903" PRELIMINARY TREATMENT COMPLEX NO. 2 SLUDGE DISCHARGE FLOW FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	12	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	13	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	14	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-01	16	
SURGE PROTECTION DEVICE "FEC2-SPD-PDP1" SPD FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	01	
AUTOMATIC TRANSFER SWITCH "FEC2-ATS-001" NORMAL STATUS	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	02	
AUTOMATIC TRANSFER SWITCH "FEC2-ATS-001" EMERGENCY STATUS	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	06	
"FEC2-PS-LPU1" 24VDC PRIMARY POWER SUPPLY FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	08	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	12	
UNINTERRUPTIBLE POWER SUPPLY "FEC2-UPS-LPU1" LOW BATTERY ALARM	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	13	
UNINTERRUPTIBLE POWER SUPPLY "FEC2-UPS-LPU1" POWER FAILURE ALARM	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	14	
UNINTERRUPTIBLE POWER SUPPLY "FEC2-UPS-LPU1" BYPASS STATUS	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-100	DI-02	16	
"FEC2-LIT-4240" FLOW EQUALIZATION BASIN NO. 4 LEVEL	FEC2-CP-LPU1	FEC2-PLC-200	AI-01	01	
"PTC2-LIT-4041" PRIMARY BASIN NO. 4 SCUM PIT LEVEL	FEC2-CP-LPU1	FEC2-PLC-200	AI-01	02	
"FEC2-PIT-4141" PRIMARY SCUM PUMP NO. 2 DISCHARGE PRESSURE	FEC2-CP-LPU1	FEC2-PLC-200	AI-01	03	
"PTC2-AE-1207-02B" HYDROGEN SULFIDE ANALYZING ELEMENT	FEC2-CP-LPU1	FEC2-PLC-200	AI-01	04	
"PTC2-AE-1208-02B" METHANE ANALYZING ELEMENT	FEC2-CP-LPU1	FEC2-PLC-200	AI-01	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	AI-01	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	AI-01	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	AI-01	08	
CIRCUIT BREAKER "FEC2-BKR-MCC100" CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	01	
CIRCUIT BREAKER "FEC2-BKR-MCC100" OPEN STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	02	
CIRCUIT BREAKER "FEC2-BKR-MCC100" CLOSE CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	03	
CIRCUIT BREAKER "FEC2-BKR-MCC100" OPEN CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	04	
CIRCUIT BREAKER "FEC2-BKR-MCC100" OVER-CURRENT TRIP STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	05	
CIRCUIT BREAKER "FEC2-BKR-MCC100" SELECTOR SWITCH REMOTE ON POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	06	
CIRCUIT BREAKER "FEC2-BKR-MCC100" SELECTOR SWITCH REMOTE OFF POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	12	
SLUDGE COLLECTOR "PTC2-SE-003" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	13	
SLUDGE COLLECTOR "PTC2-SE-003" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	14	
SLUDGE COLLECTOR "PTC2-SE-003" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	15	
SLUDGE COLLECTOR "PTC2-SE-003" HIGH TORQUE ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-01	16	
SLUDGE COLLECTOR "FEC2-SE-031" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	01	
SLUDGE COLLECTOR "FEC2-SE-031" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	02	
SLUDGE COLLECTOR "FEC2-SE-031" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	03	
SLUDGE COLLECTOR "FEC2-SE-031" HIGH TORQUE ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	04	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	05	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	06	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" OPEN STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	07	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" CLOSE CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	08	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" OPEN CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	09	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" OVER-CURRENT TRIP STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	10	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" SELECTOR SWITCH REMOTE ON POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	11	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" SELECTOR SWITCH REMOTE OFF POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	12	
SLUDGE COLLECTOR "FEC2-SE-032" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	13	
SLUDGE COLLECTOR "FEC2-SE-032" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	14	
SLUDGE COLLECTOR "FEC2-SE-032" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	15	
SLUDGE COLLECTOR "FEC2-SE-032" HIGH TORQUE ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-02	16	
ODOR CONTROL BLOWER "PTC2-OCA-001" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	01	
ODOR CONTROL BLOWER "PTC2-OCA-001" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	02	
ODOR CONTROL BLOWER "PTC2-OCA-001" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	03	
ODOR CONTROL BLOWER "PTC2-OCA-001" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	04	
ODOR CONTROL BLOWER "PTC2-OCA-001" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	11	
ODOR CONTROL BLOWER "PTC2-OCA-003" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	12	
ODOR CONTROL BLOWER "PTC2-OCA-003" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	13	
ODOR CONTROL BLOWER "PTC2-OCA-003" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	14	
ODOR CONTROL BLOWER "PTC2-OCA-003" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	15	
ODOR CONTROL BLOWER "PTC2-OCA-003" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-03	16	
ODOR CONTROL BLOWER "PTC2-OCA-005" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	01	
ODOR CONTROL BLOWER "PTC2-OCA-005" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	02	
ODOR CONTROL BLOWER "PTC2-OCA-005" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	03	
ODOR CONTROL BLOWER "PTC2-OCA-005" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	04	
ODOR CONTROL BLOWER "PTC2-OCA-005" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	08	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	11	
ODOR CONTROL BLOWER "PTC2-OCA-007" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	12	
ODOR CONTROL BLOWER "PTC2-OCA-007" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	13	
ODOR CONTROL BLOWER "PTC2-OCA-007" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	14	
ODOR CONTROL BLOWER "PTC2-OCA-007" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	15	
ODOR CONTROL BLOWER "PTC2-OCA-007" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-04	16	
SCUM PUMP "FEC2-SCP-002" SELECTOR SWITCH LOCAL POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	01	
SCUM PUMP "FEC2-SCP-002" SELECTOR SWITCH REMOTE POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	02	
SCUM PUMP "FEC2-SCP-002" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	03	
SCUM PUMP "FEC2-SCP-002" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	04	
SCUM PUMP "FEC2-SCP-002" MOTOR OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	05	
SCUM PUMP "FEC2-SCP-002" HIGH WINDING TEMPERATURE ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	06	
SCUM PUMP "FEC2-SCP-002" STATOR TEMPERATURE (DRY RUN PROTECTION)	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	07	
SCUM PUMP "FEC2-SCP-002" HIGH-HIGH DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	08	
SCUM PUMP "FEC2-SCP-002" LOW-LOW DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	09	
SCUM PUMP "FEC2-SCP-002" LOCKOUT ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	10	
SCUM PUMP "FEC2-SCP-002" PFCC CONTACTOR CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	11	
SCUM PUMP "FEC2-SCP-002" PFCC OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	12	
SCUM PUMP "FEC2-SCP-002" PFCC FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	13	
SCUM PUMP "FEC2-SCP-002" LOW-LOW SCUM PIT LEVEL ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	14	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-05	16	
ODOR CONTROL BLOWER "PTC2-OCA-009" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	01	
ODOR CONTROL BLOWER "PTC2-OCA-009" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	02	
ODOR CONTROL BLOWER "PTC2-OCA-009" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	03	
ODOR CONTROL BLOWER "PTC2-OCA-009" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	04	
ODOR CONTROL BLOWER "PTC2-OCA-009" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	11	
MACERATOR "FEC2-MRT-002" MOTOR RUNNING FORWARD STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	12	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
MACERATOR "FEC2-MRT-002" MOTOR RUNNING REVERSE STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	13	
MACERATOR "FEC2-MRT-002" COMMON ALARM	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	14	
MACERATOR "FEC2-MRT-002" REMOTE POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	15	
MACERATOR "FEC2-MRT-002" MOTOR REMOTE CONTROL STATUS	FEC2-CP-LPU1	FEC2-PLC-200	DI-06	16	
SLUDGE COLLECTOR "PTC2-SE-003" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-01	01	
SLUDGE COLLECTOR "PTC2-SE-003" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-01	02	
SLUDGE COLLECTOR "FEC2-SE-031" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-01	03	
SLUDGE COLLECTOR "FEC2-SE-031" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-01	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DO-01	05	
ODOR CONTROL BLOWER "PTC2-OCA-001" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-01	06	
ODOR CONTROL BLOWER "PTC2-OCA-001" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-01	07	
ODOR CONTROL BLOWER "PTC2-OCA-001" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-01	08	
SLUDGE COLLECTOR "FEC2-SE-032" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-02	01	
SLUDGE COLLECTOR "FEC2-SE-032" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-02	02	
CIRCUIT BREAKER "FEC2-BKR-MCC100" CLOSE COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-02	03	
CIRCUIT BREAKER "FEC2-BKR-MCC100" OPEN COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-02	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DO-02	05	
ODOR CONTROL BLOWER "PTC2-OCA-003" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-02	06	
ODOR CONTROL BLOWER "PTC2-OCA-003" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-02	07	
ODOR CONTROL BLOWER "PTC2-OCA-003" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-02	08	
ODOR CONTROL BLOWER "PTC2-OCA-005" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-03	01	
ODOR CONTROL BLOWER "PTC2-OCA-005" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-03	02	
ODOR CONTROL BLOWER "PTC2-OCA-005" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-03	03	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" CLOSE COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-03	04	
CIRCUIT BREAKER "FEC2-BKR-TMCC100" OPEN COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-03	05	
ODOR CONTROL BLOWER "PTC2-OCA-007" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-03	06	
ODOR CONTROL BLOWER "PTC2-OCA-007" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-03	07	
ODOR CONTROL BLOWER "PTC2-OCA-007" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-03	08	
ODOR CONTROL BLOWER "PTC2-OCA-009" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-04	01	
ODOR CONTROL BLOWER "PTC2-OCA-009" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-04	02	
ODOR CONTROL BLOWER "PTC2-OCA-009" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-04	03	
MACERATOR "FEC2-MRT-002" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-04	04	
MACERATOR "FEC2-MRT-002" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-04	05	
	FEC2-CP-LPU1	FEC2-PLC-200	DO-04	06	
SCUM PUMP "FEC2-SCP-002" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-200	DO-04	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-200	DO-04	08	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"PTC2-LIT-3741" PRIMARY CLARIFIER NO. 4 SLUDGE BLANKET LEVEL	FEC2-CP-LPU1	FEC2-PLC-300	AI-01	01	
"FEC2-LIT-4241" FLOW EQUALIZATION BASIN NO. 4 LEVEL	FEC2-CP-LPU1	FEC2-PLC-300	AI-01	02	
"FEC2-AIT-3932" PTC2 SLUDGE PUMP NO. 3 DISCHARGE SUSPENDED SOLIDS ANALYZER	FEC2-CP-LPU1	FEC2-PLC-300	AI-01	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	AI-01	04	
"FEC2-PIT-3931" PRIMARY SLUDGE PUMP NO. 3 DISCHARGE PRESSURE	FEC2-CP-LPU1	FEC2-PLC-300	AI-01	05	
"PTC2-AE-1207-02C" HYDROGEN SULFIDE ANALYZING ELEMENT	FEC2-CP-LPU1	FEC2-PLC-300	AI-01	06	
"PTC2-AE-1208-02C" METHANE ANALYZING ELEMENT	FEC2-CP-LPU1	FEC2-PLC-300	AI-01	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	AI-01	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	AO-01	01	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	AO-01	02	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	AO-01	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	AO-01	04	
SLUDGE COLLECTOR "PTC2-SE-004" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	01	
SLUDGE COLLECTOR "PTC2-SE-004" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	02	
SLUDGE COLLECTOR "PTC2-SE-004" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	03	
SLUDGE COLLECTOR "PTC2-SE-004" HIGH TORQUE ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	07	
PTC2 BUILDING "FEC2-LCP-SP" SUMP PUMP NO. 1 MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	08	
PTC2 BUILDING "FEC2-LCP-SP" SUMP PUMP NO. 2 MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	09	
PTC2 BUILDING "FEC2-LCP-SP" SUMP HIGH LEVEL ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	12	
SLUDGE COLLECTOR "FEC2-SE-041" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	13	
SLUDGE COLLECTOR "FEC2-SE-041" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	14	
SLUDGE COLLECTOR "FEC2-SE-041" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	15	
SLUDGE COLLECTOR "FEC2-SE-041" HIGH TORQUE ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-01	16	
SLUDGE COLLECTOR "FEC2-SE-042" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	01	
SLUDGE COLLECTOR "FEC2-SE-042" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	02	
SLUDGE COLLECTOR "FEC2-SE-042" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	03	
SLUDGE COLLECTOR "FEC2-SE-042" HIGH TORQUE ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	08	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	12	
BLOWER SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	13	
BLOWER MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	14	
BLOWER MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	15	
BLOWER MOTOR OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-02	16	
ODOR CONTROL BLOWER "PTC2-OCA-002" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	01	
ODOR CONTROL BLOWER "PTC2-OCA-002" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	02	
ODOR CONTROL BLOWER "PTC2-OCA-002" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	03	
ODOR CONTROL BLOWER "PTC2-OCA-002" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	04	
ODOR CONTROL BLOWER "PTC2-OCA-002" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	11	
ODOR CONTROL BLOWER "PTC2-OCA-004" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	12	
ODOR CONTROL BLOWER "PTC2-OCA-004" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	13	
ODOR CONTROL BLOWER "PTC2-OCA-004" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	14	
ODOR CONTROL BLOWER "PTC2-OCA-004" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	15	
ODOR CONTROL BLOWER "PTC2-OCA-004" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-03	16	
ODOR CONTROL BLOWER "PTC2-OCA-006" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	01	
ODOR CONTROL BLOWER "PTC2-OCA-006" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	02	
ODOR CONTROL BLOWER "PTC2-OCA-006" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	03	
ODOR CONTROL BLOWER "PTC2-OCA-006" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	04	
ODOR CONTROL BLOWER "PTC2-OCA-006" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	11	
ODOR CONTROL BLOWER "PTC2-OCA-008" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	12	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
ODOR CONTROL BLOWER "PTC2-OCA-008" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	13	
ODOR CONTROL BLOWER "PTC2-OCA-008" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	14	
ODOR CONTROL BLOWER "PTC2-OCA-008" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	15	
ODOR CONTROL BLOWER "PTC2-OCA-008" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-04	16	
ODOR CONTROL BLOWER "PTC2-OCA-010" SELECTOR SWITCH AUTO POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	01	
ODOR CONTROL BLOWER "PTC2-OCA-010" MOTOR RUNNING SLOW STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	02	
ODOR CONTROL BLOWER "PTC2-OCA-010" MOTOR RUNNING FAST STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	03	
ODOR CONTROL BLOWER "PTC2-OCA-010" MOTOR OVERLOAD SLOW ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	04	
ODOR CONTROL BLOWER "PTC2-OCA-010" MOTOR OVERLOAD FAST ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	12	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	13	
SLUDGE PUMP "FEC2-SLP-003" PFCC CONTACTOR CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	14	
SLUDGE PUMP "FEC2-SLP-003" PFCC OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	15	
SLUDGE PUMP "FEC2-SLP-003" PFCC FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-05	16	
SLUDGE PUMP "FEC2-SLP-003" SELECTOR SWITCH LOCAL POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	01	
SLUDGE PUMP "FEC2-SLP-003" SELECTOR SWITCH REMOTE POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	02	
SLUDGE PUMP "FEC2-SLP-003" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	03	
SLUDGE PUMP "FEC2-SLP-003" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	04	
SLUDGE PUMP "FEC2-SLP-003" MOTOR OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	05	
SLUDGE PUMP "FEC2-SLP-003" HIGH WINDING TEMPERATURE ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	06	
SLUDGE PUMP "FEC2-SLP-003" STATOR TEMPERATURE (DRY RUN PROTECTION)	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	07	
SLUDGE PUMP "FEC2-SLP-003" HIGH-HIGH DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	08	
SLUDGE PUMP "FEC2-SLP-003" LOW-LOW DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	09	
SLUDGE PUMP "FEC2-SLP-003" LOCKOUT ALARM	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	10	
SLUDGE PUMP "FEC2-SLP-003" POWER FACTOR CORRECTION	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	12	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	13	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	14	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DI-06	16	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SLUDGE COLLECTOR "PTC2-SE-004" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-01	01	
SLUDGE COLLECTOR "PTC2-SE-004" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-01	02	
SLUDGE COLLECTOR "FEC2-SE-041" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-01	03	
SLUDGE COLLECTOR "FEC2-SE-041" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-01	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-01	05	
ODOR CONTROL BLOWER "PTC2-OCA-002" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-01	06	
ODOR CONTROL BLOWER "PTC2-OCA-002" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-01	07	
ODOR CONTROL BLOWER "PTC2-OCA-002" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-01	08	
SLUDGE COLLECTOR "FEC2-SE-042" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-02	01	
SLUDGE COLLECTOR "FEC2-SE-042" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-02	02	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-02	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-02	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-02	05	
ODOR CONTROL BLOWER "PTC2-OCA-004" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-02	06	
ODOR CONTROL BLOWER "PTC2-OCA-004" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-02	07	
ODOR CONTROL BLOWER "PTC2-OCA-004" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-02	08	
ODOR CONTROL BLOWER "PTC2-OCA-006" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-03	01	
ODOR CONTROL BLOWER "PTC2-OCA-006" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-03	02	
ODOR CONTROL BLOWER "PTC2-OCA-006" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-03	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-03	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-03	05	
ODOR CONTROL BLOWER "PTC2-OCA-008" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-03	06	
ODOR CONTROL BLOWER "PTC2-OCA-008" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-03	07	
ODOR CONTROL BLOWER "PTC2-OCA-008" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-03	08	
ODOR CONTROL BLOWER "PTC2-OCA-010" START SLOW SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-04	01	
ODOR CONTROL BLOWER "PTC2-OCA-010" START FAST SPEED COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-04	02	
ODOR CONTROL BLOWER "PTC2-OCA-010" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-04	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-04	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-04	05	
SLUDGE PUMP "FEC2-SLP-003" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-04	06	
SLUDGE PUMP "FEC2-SLP-003" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-300	DO-04	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-300	DO-04	08	
"PTC2-LIT-3731" PRIMARY CLARIFIER NO. 3 SLUDGE BLANKET LEVEL	FEC2-CP-LPU1	FEC2-PLC-400	AI-01	01	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AI-01	02	
"FEC2-AIT-3912" PTC2 SLUDGE PUMP NO. 1 DISCHARGE SUSPENDED SOLIDS ANALYZER	FEC2-CP-LPU1	FEC2-PLC-400	AI-01	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AI-01	04	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"FEC2-PIT-3911" PRIMARY SLUDGE PUMP NO. 1 DISCHARGE PRESSURE	FEC2-CP-LPU1	FEC2-PLC-400	AI-01	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AI-01	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AI-01	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AI-01	08	
"FEC2-LIT-4231" FLOW EQUALIZATION BASIN NO. 3 LEVEL	FEC2-CP-LPU1	FEC2-PLC-400	AI-02	01	
"FEC2-AIT-3922" PTC2 SLUDGE PUMP NO. 2 DISCHARGE SUSPENDED SOLIDS ANALYZER	FEC2-CP-LPU1	FEC2-PLC-400	AI-02	02	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AI-02	03	
"FEC2-PIT-3921" PRIMARY SLUDGE PUMP NO. 2 DISCHARGE PRESSURE	FEC2-CP-LPU1	FEC2-PLC-400	AI-02	04	
"PTC2-LIT-4031" PRIMARY BASIN NO. 3 SCUM PIT LEVEL	FEC2-CP-LPU1	FEC2-PLC-400	AI-02	05	
"FEC2-PIT-4131" PRIMARY SCUM PUMP NO. 1 DISCHARGE PRESSURE	FEC2-CP-LPU1	FEC2-PLC-400	AI-02	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AI-02	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AI-02	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AO-01	01	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AO-01	02	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AO-01	03	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	AO-01	04	
SURGE PROTECTION DEVICE "FEC2-SPD-MCC200" SPD FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	01	
POWER MONITORING UNIT "FEC2-PMU-MCC200" POWER FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	02	
CIRCUIT BREAKER "FEC2-BKR-MCC200" CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	03	
CIRCUIT BREAKER "FEC2-BKR-MCC200" OPEN STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	04	
CIRCUIT BREAKER "FEC2-BKR-MCC200" SPRING CHARGED STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	05	
CIRCUIT BREAKER "FEC2-BKR-MCC200" OVER-CURRENT TRIP STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	06	
CIRCUIT BREAKER "FEC2-BKR-MCC200" SELECTOR SWITCH REMOTE ON POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	07	
CIRCUIT BREAKER "FEC2-BKR-MCC200" SELECTOR SWITCH REMOTE OFF POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	12	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	13	
SLUDGE PUMP "FEC2-SLP-001" PFCC CONTACTOR CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	14	
SLUDGE PUMP "FEC2-SLP-001" PFCC OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	15	
SLUDGE PUMP "FEC2-SLP-001" PFCC FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-01	16	
SLUDGE PUMP "FEC2-SLP-001" SELECTOR SWITCH LOCAL POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	01	
SLUDGE PUMP "FEC2-SLP-001" SELECTOR SWITCH REMOTE POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	02	
SLUDGE PUMP "FEC2-SLP-001" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	03	
SLUDGE PUMP "FEC2-SLP-001" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	04	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SLUDGE PUMP "FEC2-SLP-001" MOTOR OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	05	
SLUDGE PUMP "FEC2-SLP-001" HIGH WINDING TEMPERATURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	06	
SLUDGE PUMP "FEC2-SLP-001" STATOR TEMPERATURE (DRY RUN PROTECTION)	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	07	
SLUDGE PUMP "FEC2-SLP-001" HIGH-HIGH DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	08	
SLUDGE PUMP "FEC2-SLP-001" LOW-LOW DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	09	
SLUDGE PUMP "FEC2-SLP-001" LOCKOUT ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	10	
SLUDGE PUMP "FEC2-SLP-001" POWER FACTOR CORRECTION	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	12	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	13	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	14	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-02	16	
SLUDGE PUMP "FEC2-SLP-002" SELECTOR SWITCH LOCAL POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	01	
SLUDGE PUMP "FEC2-SLP-002" SELECTOR SWITCH REMOTE POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	02	
SLUDGE PUMP "FEC2-SLP-002" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	03	
SLUDGE PUMP "FEC2-SLP-002" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	04	
SLUDGE PUMP "FEC2-SLP-002" MOTOR OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	05	
SLUDGE PUMP "FEC2-SLP-002" HIGH WINDING TEMPERATURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	06	
SLUDGE PUMP "FEC2-SLP-002" STATOR TEMPERATURE (DRY RUN PROTECTION)	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	07	
SLUDGE PUMP "FEC2-SLP-002" HIGH-HIGH DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	08	
SLUDGE PUMP "FEC2-SLP-002" LOW-LOW DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	09	
SLUDGE PUMP "FEC2-SLP-002" LOCKOUT ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	10	
SLUDGE PUMP "FEC2-SLP-002" POWER FACTOR CORRECTION	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	12	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	13	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	14	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-03	16	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	01	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	02	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	03	
SLUDGE PUMP "FEC2-SLP-002" PFCC CONTACTOR CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	04	
SLUDGE PUMP "FEC2-SLP-002" PFCC OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	05	
SLUDGE PUMP "FEC2-SLP-002" PFCC FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	07	
CIRCUIT BREAKER "FEC2-BKR-TMCC200" CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	08	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
CIRCUIT BREAKER "FEC2-BKR-TMCC200" OPEN STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	09	
CIRCUIT BREAKER "FEC2-BKR-TMCC200" SPRING CHARGED STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	10	
CIRCUIT BREAKER "FEC2-BKR-TMCC200" OVER-CURRENT TRIP STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	11	
CIRCUIT BREAKER "FEC2-BKR-TMCC200" SELECTOR SWITCH REMOTE ON POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	12	
CIRCUIT BREAKER "FEC2-BKR-TMCC200" SELECTOR SWITCH REMOTE OFF POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	13	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	14	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-04	16	
SCUM PUMP "FEC2-SCP-001" SELECTOR SWITCH LOCAL POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	01	
SCUM PUMP "FEC2-SCP-001" SELECTOR SWITCH REMOTE POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	02	
SCUM PUMP "FEC2-SCP-001" MOTOR CONTROL RELAY STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	03	
SCUM PUMP "FEC2-SCP-001" MOTOR RUNNING STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	04	
SCUM PUMP "FEC2-SCP-001" MOTOR OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	05	
SCUM PUMP "FEC2-SCP-001" HIGH WINDING TEMPERATURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	06	
SCUM PUMP "FEC2-SCP-001" STATOR TEMPERATURE (DRY RUN PROTECTION)	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	07	
SCUM PUMP "FEC2-SCP-001" HIGH-HIGH DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	08	
SCUM PUMP "FEC2-SCP-001" LOW-LOW DISCHARGE PRESSURE ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	09	
SCUM PUMP "FEC2-SCP-001" LOCKOUT ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	10	
SCUM PUMP "FEC2-SCP-001" PFCC CONTACTOR CLOSED STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	11	
SCUM PUMP "FEC2-SCP-001" PFCC OVERLOAD ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	12	
SCUM PUMP "FEC2-SCP-001" PFCC FAIL ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	13	
SCUM PUMP "FEC2-SCP-001" LOW-LOW SCUM PIT LEVEL ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	14	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-05	16	
MACERATOR "FEC2-MRT-001" MOTOR RUNNING FORWARD STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	01	
MACERATOR "FEC2-MRT-001" MOTOR RUNNING REVERSE STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	02	
MACERATOR "FEC2-MRT-001" COMMON ALARM	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	03	
MACERATOR "FEC2-MRT-001" REMOTE POSITION STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	04	
MACERATOR "FEC2-MRT-001" MOTOR REMOTE CONTROL STATUS	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	05	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	06	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	07	
SPARE SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	08	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	09	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	10	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	11	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	12	

FLOW EQUALIZATION COMPLEX NO. 2

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	13	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	14	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	15	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DI-06	16	
SCUM PUMP "FEC2-SCP-001" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-01	01	
SCUM PUMP "FEC2-SCP-001" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-01	02	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DO-01	03	
CIRCUIT BREAKER "FEC2-BKR-MCC200" CLOSE COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-01	04	
CIRCUIT BREAKER "FEC2-BKR-MCC200" OPEN COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-01	05	
SLUDGE PUMP "FEC2-SLP-001" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-01	06	
SLUDGE PUMP "FEC2-SLP-001" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-01	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DO-01	08	
MACERATOR "FEC2-MRT-001" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-02	01	
MACERATOR "FEC2-MRT-001" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-02	02	
CIRCUIT BREAKER "FEC2-BKR-TMCC200" CLOSE COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-02	03	
CIRCUIT BREAKER "FEC2-BKR-TMCC200" OPEN COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-02	04	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DO-02	05	
SLUDGE PUMP "FEC2-SLP-002" START COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-02	06	
SLUDGE PUMP "FEC2-SLP-002" STOP COMMAND	FEC2-CP-LPU1	FEC2-PLC-400	DO-02	07	
SPARE	FEC2-CP-LPU1	FEC2-PLC-400	DO-02	08	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"OP-PIT-1621" COOLANT SUPPLY HEADER PRESURE	OP-CP-LPU1	OP-PLC-LPU1	AI-01	01	X
"OP-PIT-1605" DISCHARGE AIR HEADER PRESSURE	OP-CP-LPU1	OP-PLC-LPU1	AI-01	02	X
"OP-FIT-1625-01" COOLING WATER PUMP DISCHARGE HEADER FLOW RATE	OP-CP-LPU1	OP-PLC-LPU1	AI-01	03	X
"OP-TIT-1692" NPW WATER HEAT EXCHANGER COOLANT SUPPLY TEMPERATURE	OP-CP-LPU1	OP-PLC-LPU1	AI-01	04	
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-01	05	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-01	06	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-01	07	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-01	08	X
"OP-PIT-1622" COOLING WATER HEADER PRESSURE	OP-CP-LPU1	OP-PLC-LPU1	AI-02	01	X
"OP-TIT-1627" COOLING WATER TEMPERATURE	OP-CP-LPU1	OP-PLC-LPU1	AI-02	02	X
"OP-FIT-1625-02" COOLING HEADER WATER FLOW RATE	OP-CP-LPU1	OP-PLC-LPU1	AI-02	03	X
"OP-TIT-1693" NPW WATER HEAT EXCHANGER COOLANT RETURN TEMPERATURE	OP-CP-LPU1	OP-PLC-LPU1	AI-02	04	
"OP-PIT-1694" NPW WATER HEAT EXCHANGER COOLANT RETURN PRESSURE	OP-CP-LPU1	OP-PLC-LPU1	AI-02	05	
"OP-FIT-1696" NPW HEAT EXCHANGER COOLANT RETURN TO CHLORINE EJECTORS FLOW RATE	OP-CP-LPU1	OP-PLC-LPU1	AI-02	06	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-02	07	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-02	08	X
"OP-TIT-1623" COOLING WATER HEADER TEMPERATURE	OP-CP-LPU1	OP-PLC-LPU1	AI-03	01	X
"OP-LITC-1624" COOLING WATER TANK LEVEL	OP-CP-LPU1	OP-PLC-LPU1	AI-03	02	X
"OP-PIT-1620" COOLING WATER PRESSURE	OP-CP-LPU1	OP-PLC-LPU1	AI-03	03	X
"OP-PIT-1635" CONTROL AIR PRESSURE	OP-CP-LPU1	OP-PLC-LPU1	AI-03	04	X
"OP-FIT-1695" NPW WATER HEAT EXCHANGER COOLANT RETURN TO FLOW EQUALIZATION FLOW	OP-CP-LPU1	OP-PLC-LPU1	AI-03	05	
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-03	06	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-03	07	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	AI-03	08	X
"CWP-001" MOTOR OVERLOAD STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-01	01	X
"CWP-001" HAND POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-01	02	X
"CWP-001" OFF POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-01	03	X
"CWP-001" REMOTE POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-01	04	X
"CWP-001" MOTOR ON STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-01	05	X
"CWP-001" MOTOR OFF STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-01	06	X
"OP-LSLL-1624" COOLING WATER TANK LOW-LOW LEVEL ALARM	OP-CP-LPU1	OP-PLC-LPU1	DI-01	07	X
"VF-006" MOTOR ON STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-01	08	X
"VF-006" MOTOR OFF STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-01	09	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-01	10	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-01	11	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-01	12	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-01	13	X
"OP-BPS-LPU1" UPS IN BYPASS ALARM	OP-CP-LPU1	OP-PLC-LPU1	DI-01	14	X
"OP-BPS-LPU1" UPS POWER SUPPLY FAIL ALARM	OP-CP-LPU1	OP-PLC-LPU1	DI-01	15	X
"OP-24VDC-LPU1" 24VDS POWER SUPPLY FAIL ALARM	OP-CP-LPU1	OP-PLC-LPU1	DI-01	16	X
"CWP-002" MOTOR OVERLOAD STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-02	01	X
"CWP-002" HAND POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-02	02	X
"CWP-002" OFF POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-02	03	X
"CWP-002" REMOTE POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-02	04	X
"CWP-002" MOTOR ON STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-02	05	X
"CWP-002" MOTOR OFF STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-02	06	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-02	07	X
"VF-007" MOTOR ON STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-02	08	X
"VF-007" MOTOR OFF STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-02	09	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-02	10	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-02	11	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-02	12	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-02	13	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-02	14	X
"OP-FIT-1695" NPW WATER HEAT EXCHANGER COOLANT RETURN TO FLOW EQUALIZATION FLOW FAIL ALARM	OP-CP-LPU1	OP-PLC-LPU1	DI-02	15	
"OP-FIT-1696" NPW HEAT EXCHANGER COOLANT RETURN TO CHLORINE EJECTORS FLOW RATE FAIL ALARM	OP-CP-LPU1	OP-PLC-LPU1	DI-02	16	
"CWP-003" MOTOR OVERLOAD STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-03	01	X
"CWP-003" HAND POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-03	02	X
"CWP-003" OFF POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-03	03	X
"CWP-003" REMOTE POSITION STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-03	04	X
"CWP-003" MOTOR ON STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-03	05	X
"CWP-003" MOTOR OFF STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-03	06	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-03	07	X
"VF-008" MOTOR ON STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-03	08	X
"VF-008" MOTOR OFF STATUS	OP-CP-LPU1	OP-PLC-LPU1	DI-03	09	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-03	10	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-03	11	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-03	12	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-03	13	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-03	14	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-03	15	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DI-03	16	X
COOLING WATER PUMP NO. 1 START	OP-CP-LPU1	OP-PLC-LPU1	DO-01	01	X
COOLING WATER PUMP NO. 1 STOP	OP-CP-LPU1	OP-PLC-LPU1	DO-01	02	X
COOLING WATER PUMP NO. 2 START	OP-CP-LPU1	OP-PLC-LPU1	DO-01	03	X
COOLING WATER PUMP NO. 2 STOP	OP-CP-LPU1	OP-PLC-LPU1	DO-01	04	X
"OP-SV-MWV1" OPEN/CLOSE SOLENOID VALVE	OP-CP-LPU1	OP-PLC-LPU1	DO-01	05	DEMO
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-01	06	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-01	07	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-01	08	X
COOLING WATER PUMP NO. 3 START	OP-CP-LPU1	OP-PLC-LPU1	DO-02	01	X
COOLING WATER PUMP NO. 3 STOP	OP-CP-LPU1	OP-PLC-LPU1	DO-02	02	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-02	03	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-02	04	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-02	05	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-02	06	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-02	07	X
SPARE	OP-CP-LPU1	OP-PLC-LPU1	DO-02	08	X
"OP-ZI-1673-01" SETTLED WASTEWATER DISCHARGE VALVE POSITION INPUT 0-100%	OP-CP-LPU2	OP-PLC-LPU2	AI-01	01	X
"OP-FIT-1673-01" SETTLED WASTEWATER ULTRASONIC FLOW	OP-CP-LPU2	OP-PLC-LPU2	AI-01	02	X
"OP-PDIT-1690-01" SCRUBBER STAGE 1 FILTER DIFFERENTIAL PRESSURE	OP-CP-LPU2	OP-PLC-LPU2	AI-01	03	X
"OP-TIT-1690" AMBIENT TEMPERATURE	OP-CP-LPU2	OP-PLC-LPU2	AI-01	04	X
"OP-FIT-1673-02" SETTLED WASTEWATER ULTRASONIC FLOW	OP-CP-LPU2	OP-PLC-LPU2	AI-01	05	
SPARE	OP-CP-LPU2	OP-PLC-LPU2	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-LPU2	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-LPU2	AI-01	08	X
"BFV-035" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-LPU2	DI-03	01	X
"BFV-035" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-LPU2	DI-03	02	X
"BFV-035" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-LPU2	DI-03	03	X
"BFV-035" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-LPU2	DI-03	04	X
"BFV-035" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-LPU2	DI-03	05	X
"BFV-035" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-LPU2	DI-03	06	X
"BFV-035" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-LPU2	DI-03	07	X
"BFV-035" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-LPU2	DI-03	08	X
"BFV-035" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-LPU2	DI-03	09	X
"BFV-035" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-LPU2	DI-03	10	X
"BFV-035" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-LPU2	DI-03	11	X
"OP-FIT-1673-01" SETTLED WASTEWATER ULTRASONIC FLOW INDICATING TRANSMITTER FAIL ALARM	OP-CP-LPU2	OP-PLC-LPU2	DI-03	12	X
"OP-FIT-1673-02" SETTLED WASTEWATER ULTRASONIC FLOW INDICATING TRANSMITTER FAIL ALARM	OP-CP-LPU2	OP-PLC-LPU2	DI-03	13	X
"OP-BPS-LPU2" UPS IN BYPASS ALARM	OP-CP-LPU2	OP-PLC-LPU2	DI-03	14	X
"OP-UPS-LPU2" UPS POWER SUPPLY FAILURE ALARM	OP-CP-LPU2	OP-PLC-LPU2	DI-03	15	X
"OP-24VDC-LPU2" POWER SUPPLY FAILURE ALARM	OP-CP-LPU2	OP-PLC-LPU2	DI-03	16	X
"OP-VT-1640-01A" MOTOR NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP1	AI-01	01	X
"OP-VT-1640-01B" PUMP NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP1	AI-01	02	X
"OP-PIT-1640-01" SETTLED WATER PUMP NO. 1 SUCTION PRESSURE	OP-CP-LPU2	OP-PLC-SWP1	AI-01	03	X
"OP-PIT-1641-01" SETTLED WATER PUMP NO. 1 DISCHARGE PRESSURE	OP-CP-LPU2	OP-PLC-SWP1	AI-01	04	
SPARE	OP-CP-LPU2	OP-PLC-SWP1	AI-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	AI-01	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	DI-02	01	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"BFV-055" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	02	X
"BFV-055" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-SWP1	DI-02	03	X
"BFV-055" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	04	X
"BFV-055" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	05	X
"BFV-055" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-SWP1	DI-02	06	X
"BFV-055" 95% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	DI-02	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	DI-02	09	X
"BFV-055" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	10	X
"BFV-055" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	11	X
"BFV-055" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	12	X
"BFV-055" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	13	X
"BFV-055" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-SWP1	DI-02	14	X
"BFV-055" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP1	DI-02	15	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	DI-02	16	X
"SWP-001" START SIGNAL	OP-CP-LPU2	OP-PLC-SWP1	DO-01	01	X
"SWP-001" STOP SIGNAL	OP-CP-LPU2	OP-PLC-SWP1	DO-01	02	X
"OP-PLC-SWP1" FAIL ALARM	OP-CP-LPU2	OP-PLC-SWP1	DO-01	03	X
"SV-SWP1" OPEN AND CLOSE SEAL WATER SOLENOID VALVE	OP-CP-LPU2	OP-PLC-SWP1	DO-01	04	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	DO-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP1	DO-01	06	X
"BFV-055" OPEN COMMAND	OP-CP-LPU2	OP-PLC-SWP1	DO-01	07	X
"BFV-055" CLOSE COMMAND	OP-CP-LPU2	OP-PLC-SWP1	DO-01	08	X
"OP-VT-1640-02A" MOTOR NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP2	AI-01	01	X
"OP-VT-1640-02B" PUMP NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP2	AI-01	02	X
"OP-PIT-1640-02" SETTLED WATER PUMP NO. 2 SUCTION PRESSURE	OP-CP-LPU2	OP-PLC-SWP2	AI-01	03	X
"OP-PIT-1641-02" SETTLED WATER PUMP NO. 2 DISCHARGE PRESSURE	OP-CP-LPU2	OP-PLC-SWP2	AI-01	04	
SPARE	OP-CP-LPU2	OP-PLC-SWP2	AI-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	AI-01	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	DI-02	01	X
"BFV-054" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	02	X
"BFV-054" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-SWP2	DI-02	03	X
"BFV-054" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	04	X
"BFV-054" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	05	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"BFV-054" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-SWP2	DI-02	06	X
"BFV-054" 95% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	DI-02	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	DI-02	09	X
"BFV-054" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	10	X
"BFV-054" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	11	X
"BFV-054" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	12	X
"BFV-054" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	13	X
"BFV-054" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-SWP2	DI-02	14	X
"BFV-054" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP2	DI-02	15	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	DI-02	16	X
"SWP-002" START SIGNAL	OP-CP-LPU2	OP-PLC-SWP2	DO-01	01	X
"SWP-002" STOP SIGNAL	OP-CP-LPU2	OP-PLC-SWP2	DO-01	02	X
"OP-PLC-SWP2" FAIL ALARM	OP-CP-LPU2	OP-PLC-SWP2	DO-01	03	X
"SV-SWP2" OPEN AND CLOSE SEAL WATER SOLENOID VALVE	OP-CP-LPU2	OP-PLC-SWP2	DO-01	04	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	DO-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP2	DO-01	06	X
"BFV-054" OPEN COMMAND	OP-CP-LPU2	OP-PLC-SWP2	DO-01	07	X
"BFV-054" CLOSE COMMAND	OP-CP-LPU2	OP-PLC-SWP2	DO-01	08	X
"OP-VT-1640-03A" MOTOR NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP3	AI-01	01	X
"OP-VT-1640-03B" PUMP NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP3	AI-01	02	X
"OP-PIT-1640-03" SETTLED WATER PUMP NO. 3 SUCTION PRESSURE	OP-CP-LPU2	OP-PLC-SWP3	AI-01	03	X
"OP-PIT-1641-03" SETTLED WATER PUMP NO. 3 DISCHARGE PRESSURE	OP-CP-LPU2	OP-PLC-SWP3	AI-01	04	
SPARE	OP-CP-LPU2	OP-PLC-SWP3	AI-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	AI-01	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	DI-02	01	X
"BFV-053" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	02	X
"BFV-053" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-SWP3	DI-02	03	X
"BFV-053" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	04	X
"BFV-053" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	05	X
"BFV-053" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-SWP3	DI-02	06	X
"BFV-053" 95% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	DI-02	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	DI-02	09	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"BFV-053" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	10	X
"BFV-053" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	11	X
"BFV-053" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	12	X
"BFV-053" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	13	X
"BFV-053" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-SWP3	DI-02	14	X
"BFV-053" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP3	DI-02	15	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	DI-02	16	X
"SWP-003" START SIGNAL	OP-CP-LPU2	OP-PLC-SWP3	DO-01	01	X
"SWP-003" STOP SIGNAL	OP-CP-LPU2	OP-PLC-SWP3	DO-01	02	X
"OP-PLC-SWP3" FAIL ALARM	OP-CP-LPU2	OP-PLC-SWP3	DO-01	03	X
"SV-SWP3" OPEN AND CLOSE SEAL WATER SOLENOID VALVE	OP-CP-LPU2	OP-PLC-SWP3	DO-01	04	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	DO-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP3	DO-01	06	X
"BFV-053" OPEN COMMAND	OP-CP-LPU2	OP-PLC-SWP3	DO-01	07	X
"BFV-053" CLOSE COMMAND	OP-CP-LPU2	OP-PLC-SWP3	DO-01	08	X
"OP-VT-1640-04A" MOTOR NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP4	AI-01	01	X
"OP-VT-1640-04B" PUMP NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP4	AI-01	02	X
"OP-PIT-1640-04" SETTLED WATER PUMP NO. 4 SUCTION PRESSURE	OP-CP-LPU2	OP-PLC-SWP4	AI-01	03	X
"OP-PIT-1641-04" SETTLED WATER PUMP NO. 4 DISCHARGE PRESSURE	OP-CP-LPU2	OP-PLC-SWP4	AI-01	04	
SPARE	OP-CP-LPU2	OP-PLC-SWP4	AI-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	AI-01	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	DI-02	01	X
"BFV-052" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	02	X
"BFV-052" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-SWP4	DI-02	03	X
"BFV-052" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	04	X
"BFV-052" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	05	X
"BFV-052" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-SWP4	DI-02	06	X
"BFV-052" 95% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	DI-02	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	DI-02	09	X
"BFV-052" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	10	X
"BFV-052" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	11	X
"BFV-052" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	12	X
"BFV-052" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	13	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"BFV-052" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-SWP4	DI-02	14	X
"BFV-052" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP4	DI-02	15	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	DI-02	16	X
"SWP-004" START SIGNAL	OP-CP-LPU2	OP-PLC-SWP4	DO-01	01	X
"SWP-004" STOP SIGNAL	OP-CP-LPU2	OP-PLC-SWP4	DO-01	02	X
"OP-PLC-SWP4" FAIL ALARM	OP-CP-LPU2	OP-PLC-SWP4	DO-01	03	X
"SV-SWP4" OPEN AND CLOSE SEAL WATER SOLENOID VALVE	OP-CP-LPU2	OP-PLC-SWP4	DO-01	04	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	DO-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP4	DO-01	06	X
"BFV-052" OPEN COMMAND	OP-CP-LPU2	OP-PLC-SWP4	DO-01	07	X
"BFV-052" CLOSE COMMAND	OP-CP-LPU2	OP-PLC-SWP4	DO-01	08	X
"OP-VT-1640-05A" MOTOR NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP5	AI-01	01	X
"OP-VT-1640-05B" PUMP NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP5	AI-01	02	X
"OP-PIT-1640-05" SETTLED WATER PUMP NO. 5 SUCTION PRESSURE INDICATING	OP-CP-LPU2	OP-PLC-SWP5	AI-01	03	X
"OP-PIT-1641-05" SETTLED WATER PUMP NO. 5 DISCHARGE PRESSURE	OP-CP-LPU2	OP-PLC-SWP5	AI-01	04	
SPARE	OP-CP-LPU2	OP-PLC-SWP5	AI-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	AI-01	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	DI-02	01	X
"BFV-051" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	02	X
"BFV-051" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-SWP5	DI-02	03	X
"BFV-051" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	04	X
"BFV-051" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	05	X
"BFV-051" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-SWP5	DI-02	06	X
"BFV-051" 95% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	DI-02	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	DI-02	09	X
"BFV-051" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	10	X
"BFV-051" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	11	X
"BFV-051" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	12	X
"BFV-051" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	13	X
"BFV-051" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-SWP5	DI-02	14	X
"BFV-051" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP5	DI-02	15	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	DI-02	16	X
"SWP-005" START SIGNAL	OP-CP-LPU2	OP-PLC-SWP5	DO-01	01	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"SWP-005" STOP SIGNAL	OP-CP-LPU2	OP-PLC-SWP5	DO-01	02	X
"OP-PLC-SWP5" FAIL ALARM	OP-CP-LPU2	OP-PLC-SWP5	DO-01	03	X
"SV-SWP5" OPEN AND CLOSE SEAL WATER SOLENOID VALVE	OP-CP-LPU2	OP-PLC-SWP5	DO-01	04	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	DO-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP5	DO-01	06	X
"BFV-051" OPEN COMMAND	OP-CP-LPU2	OP-PLC-SWP5	DO-01	07	X
"BFV-051" CLOSE COMMAND	OP-CP-LPU2	OP-PLC-SWP5	DO-01	08	X
"OP-VT-1640-06A" MOTOR NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP6	AI-01	01	X
"OP-VT-1640-06B" PUMP NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP6	AI-01	02	X
"OP-PIT-1640-06" SETTLED WATER PUMP NO. 6 SUCTION PRESSURE	OP-CP-LPU2	OP-PLC-SWP6	AI-01	03	X
"OP-PIT-1641-06" SETTLED WATER PUMP NO. 6 DISCHARGE PRESSURE	OP-CP-LPU2	OP-PLC-SWP6	AI-01	04	
SPARE	OP-CP-LPU2	OP-PLC-SWP6	AI-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP6	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-SWP6	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP6	AI-01	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP6	DI-02	01	X
"BFV-050" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	02	X
"BFV-050" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-SWP6	DI-02	03	X
"BFV-050" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	04	X
"BFV-050" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	05	X
"BFV-050" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-SWP6	DI-02	06	X
"BFV-050" 95% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP6	DI-02	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP6	DI-02	09	X
"BFV-050" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	10	X
"BFV-050" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	11	X
"BFV-050" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	12	X
"BFV-050" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	13	X
"BFV-050" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-SWP6	DI-02	14	X
"BFV-050" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP6	DI-02	15	X
SPARE	OP-CP-LPU2	OP-PLC-SWP6	DI-02	16	X
"SWP-006" START SIGNAL	OP-CP-LPU2	OP-PLC-SWP6	DO-01	01	X
"SWP-006" STOP SIGNAL	OP-CP-LPU2	OP-PLC-SWP6	DO-01	02	X
"OP-PLC-SWP6" FAIL ALARM	OP-CP-LPU2	OP-PLC-SWP6	DO-01	03	X
"SV-SWP6" OPEN AND CLOSE SEAL WATER SOLENOID VALVE	OP-CP-LPU2	OP-PLC-SWP6	DO-01	04	X
SPARE	OP-CP-LPU2	OP-PLC-SWP6	DO-01	05	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU2	OP-PLC-SWP6	DO-01	06	X
"BFV-050" OPEN COMMAND	OP-CP-LPU2	OP-PLC-SWP6	DO-01	07	X
"BFV-050" CLOSE COMMAND	OP-CP-LPU2	OP-PLC-SWP6	DO-01	08	X
"OP-VT-1640-07A" MOTOR NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP7	AI-01	01	X
"OP-VT-1640-07B" PUMP NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP7	AI-01	02	X
"OP-PIT-1640-07" SETTLED WATER PUMP NO. 7 SUCTION PRESSURE	OP-CP-LPU2	OP-PLC-SWP7	AI-01	03	X
"OP-PIT-1641-07" SETTLED WATER PUMP NO. 7 DISCHARGE PRESSURE	OP-CP-LPU2	OP-PLC-SWP7	AI-01	04	
SPARE	OP-CP-LPU2	OP-PLC-SWP7	AI-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	AI-01	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	DI-02	01	X
"BFV-057" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	02	X
"BFV-057" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-SWP7	DI-02	03	X
"BFV-057" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	04	X
"BFV-057" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	05	X
"BFV-057" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-SWP7	DI-02	06	X
"BFV-057" 95% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	DI-02	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	DI-02	09	X
"BFV-057" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	10	X
"BFV-057" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	11	X
"BFV-057" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	12	X
"BFV-057" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	13	X
"BFV-057" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-SWP7	DI-02	14	X
"BFV-057" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP7	DI-02	15	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	DI-02	16	X
"SWP-007" START SIGNAL	OP-CP-LPU2	OP-PLC-SWP7	DO-01	01	X
"SWP-007" STOP SIGNAL	OP-CP-LPU2	OP-PLC-SWP7	DO-01	02	X
"OP-PLC-SWP7" FAIL ALARM	OP-CP-LPU2	OP-PLC-SWP7	DO-01	03	X
"SV-SWP7" OPEN AND CLOSE SEAL WATER SOLENOID VALVE	OP-CP-LPU2	OP-PLC-SWP7	DO-01	04	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	DO-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP7	DO-01	06	X
"BFV-057" OPEN COMMAND	OP-CP-LPU2	OP-PLC-SWP7	DO-01	07	X
"BFV-057" CLOSE COMMAND	OP-CP-LPU2	OP-PLC-SWP7	DO-01	08	X
"OP-VT-1640-08A" MOTOR NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP8	AI-01	01	X

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"OP-VT-1640-08B" PUMP NO. 1 VIBRATION	OP-CP-LPU2	OP-PLC-SWP8	AI-01	02	X
"OP-PIT-1640-08" SETTLED WATER PUMP NO. 8 SUCTION PRESSURE	OP-CP-LPU2	OP-PLC-SWP8	AI-01	03	X
"OP-PIT-1641-08" SETTLED WATER PUMP NO. 8 DISCHARGE PRESSURE	OP-CP-LPU2	OP-PLC-SWP8	AI-01	04	
SPARE	OP-CP-LPU2	OP-PLC-SWP8	AI-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	AI-01	06	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	AI-01	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	AI-01	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	DI-02	01	X
"BFV-059" OFF POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	02	X
"BFV-059" MOTOR WINDING TEMPERATURE HIGH	OP-CP-LPU2	OP-PLC-SWP8	DI-02	03	X
"BFV-059" CLOSE MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	04	X
"BFV-059" 100% OPEN STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	05	X
"BFV-059" HIGH OPENING TORQUE	OP-CP-LPU2	OP-PLC-SWP8	DI-02	06	X
"BFV-059" 95% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	07	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	DI-02	08	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	DI-02	09	X
"BFV-059" HAND POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	10	X
"BFV-059" REMOTE POSITION STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	11	X
"BFV-059" MOTOR OVERLOAD STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	12	X
"BFV-059" 100% CLOSED STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	13	X
"BFV-059" HIGH CLOSING TORQUE	OP-CP-LPU2	OP-PLC-SWP8	DI-02	14	X
"BFV-059" OPEN MOTOR AUXILIARY STATUS	OP-CP-LPU2	OP-PLC-SWP8	DI-02	15	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	DI-02	16	X
"SWP-008" START SIGNAL	OP-CP-LPU2	OP-PLC-SWP8	DO-01	01	X
"SWP-008" STOP SIGNAL	OP-CP-LPU2	OP-PLC-SWP8	DO-01	02	X
"OP-PLC-SWP8" FAIL ALARM	OP-CP-LPU2	OP-PLC-SWP8	DO-01	03	X
"SV-SWP8" OPEN AND CLOSE SEAL WATER SOLENOID VALVE	OP-CP-LPU2	OP-PLC-SWP8	DO-01	04	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	DO-01	05	X
SPARE	OP-CP-LPU2	OP-PLC-SWP8	DO-01	06	X
"BFV-059" OPEN COMMAND	OP-CP-LPU2	OP-PLC-SWP8	DO-01	07	X
"BFV-059" CLOSE COMMAND	OP-CP-LPU2	OP-PLC-SWP8	DO-01	08	X
"FEC1-PIT-3801" PTC1 SLUDGE DISCHARGE PRESSURE	OP-CP-LPU3	OP-PLC-100	AI-01	01	
"FEC1-AIT-3802" PTC1 TOTAL SLUDGE DISCHARGE SUSPENDED SOLIDS ANALYZER	OP-CP-LPU3	OP-PLC-100	AI-01	02	
"FEC1-FIT-3803" PTC1 SLUDGE DISCHARGE FLOW	OP-CP-LPU3	OP-PLC-100	AI-01	03	
"OP-TIT-1697" OPERATIONS BUILDING ELECTRICAL ROOM AMBIENT AIR TEMPERATURE	OP-CP-LPU3	OP-PLC-100	AI-01	04	
"PTC1-AE-1207-01A" HYDROGEN SULFIDE ANALYZING ELEMENT	OP-CP-LPU3	OP-PLC-100	AI-01	05	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"PTC1-AE-1208-01A" METHANE ANALYZING ELEMENT	OP-CP-LPU3	OP-PLC-100	AI-01	06	
SPARE	OP-CP-LPU3	OP-PLC-100	AI-01	07	
"OP-LIT-4202" EXCESS FLOW WET WELL LEVEL	OP-CP-LPU3	OP-PLC-100	AI-01	08	
"FEC1-PV-105" VALVE OPEN STATUS	OP-CP-LPU3	OP-PLC-100	DI-01	01	
"FEC1-PV-105" VALVE CLOSED STATUS	OP-CP-LPU3	OP-PLC-100	DI-01	02	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-01	03	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-01	04	
"FEC1-PV-108" VALVE OPEN STATUS	OP-CP-LPU3	OP-PLC-100	DI-01	05	
"FEC1-PV-108" VALVE CLOSED STATUS	OP-CP-LPU3	OP-PLC-100	DI-01	06	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-01	07	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-01	08	
"FEC1-PV-109" VALVE OPEN STATUS	OP-CP-LPU3	OP-PLC-100	DI-01	09	
"FEC1-PV-109" VALVE CLOSED STATUS	OP-CP-LPU3	OP-PLC-100	DI-01	10	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-01	11	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-01	12	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-01	13	
"OP-LSH-1660" OPERATIONS BUILDING HIGH LEVEL ALARM	OP-CP-LPU3	OP-PLC-100	DI-01	14	
"OP-LSH-1676" RAW WASTEWATER WET WELL HIGH-HIGH LEVEL SWITCH ALARM	OP-CP-LPU3	OP-PLC-100	DI-01	15	
"FEC1-FIT-3803" PTC1 SLUDGE DISCHARGE FLOW FAIL ALARM	OP-CP-LPU3	OP-PLC-100	DI-01	16	
"OP-PS-LPU3" 24VDC PRIMARY POWER SUPPLY FAIL ALARM	OP-CP-LPU3	OP-PLC-100	DI-02	01	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	02	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	03	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	04	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	05	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	06	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	07	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	08	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	09	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	10	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	11	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	12	
UNINTERRUPTIBLE POWER SUPPLY "OP-UPS-LPU3" LOW BATTERY ALARM	OP-CP-LPU3	OP-PLC-100	DI-02	13	
UNINTERRUPTIBLE POWER SUPPLY "OP-UPS-LPU3" POWER FAILURE ALARM	OP-CP-LPU3	OP-PLC-100	DI-02	14	
UNINTERRUPTIBLE POWER SUPPLY "OP-UPS-LPU3" BYPASS STATUS	OP-CP-LPU3	OP-PLC-100	DI-02	15	
SPARE	OP-CP-LPU3	OP-PLC-100	DI-02	16	
"PTC1-LIT-3711" PRIMARY CLARIFIER NO. 1 SLUDGE BLANKET LEVEL	OP-CP-LPU3	OP-PLC-200	AI-01	01	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
"FEC1-LIT-4210" FLOW EQUALIZATION BASIN NO. 1 LEVEL	OP-CP-LPU3	OP-PLC-200	AI-01	02	
"FEC1-AIT-3812" PTC1 SLUDGE PUMP NO. 1 DISCHARGE SUSPENDED SOLIDS ANALYZER	OP-CP-LPU3	OP-PLC-200	AI-01	03	
SPARE	OP-CP-LPU3	OP-PLC-200	AI-01	04	
"FEC1-PIT-3811" PTC1 SLUDGE PUMP NO. 1 DISCHARGE PRESSURE	OP-CP-LPU3	OP-PLC-200	AI-01	05	
"OP-LIT-1675-01" RAW WASTEWATER WET WELL LEVEL - AIR BUBBLER	OP-CP-LPU3	OP-PLC-200	AI-01	06	
SLUICE GATE "FEC1-SG-001" GATE POSITION (%OPEN)	OP-CP-LPU3	OP-PLC-200	AI-01	07	
SPARE	OP-CP-LPU3	OP-PLC-200	AI-01	08	
SPARE	OP-CP-LPU3	OP-PLC-200	AO-01	01	
SLUICE GATE "FEC1-SG-001" GATE POSITION SETPOINT	OP-CP-LPU3	OP-PLC-200	AO-01	02	
SPARE	OP-CP-LPU3	OP-PLC-200	AO-01	03	
SPARE	OP-CP-LPU3	OP-PLC-200	AO-01	04	
SLUDGE COLLECTOR "PTC1-SE-001" SELECTOR SWITCH AUTO POSITION STATUS	OP-CP-LPU3	OP-PLC-200	DI-01	01	
SLUDGE COLLECTOR "PTC1-SE-001" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-200	DI-01	02	
SLUDGE COLLECTOR "PTC1-SE-001" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-200	DI-01	03	
SLUDGE COLLECTOR "PTC1-SE-001" HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-200	DI-01	04	
SLUDGE COLLECTOR "PTC1-SE-001" HIGH-HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-200	DI-01	05	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-01	06	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-01	07	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-01	08	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-01	09	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-01	10	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-01	11	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-01	12	
RAW WASTEWATER WET WELL AIR BUBBLER LOW LEVEL SHUT-OFF STATUS	OP-CP-LPU3	OP-PLC-200	DI-01	13	
RAW WASTEWATER PUMP "RWP-1" SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-200	DI-01	14	
RAW WASTEWATER PUMP "RWP-1" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-200	DI-01	15	
RAW WASTEWATER PUMP "RWP-1" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-200	DI-01	16	
SLUDGE COLLECTOR "FEC1-SE-011" SELECTOR SWITCH AUTO POSITION STATUS	OP-CP-LPU3	OP-PLC-200	DI-02	01	
SLUDGE COLLECTOR "FEC1-SE-011" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-200	DI-02	02	
SLUDGE COLLECTOR "FEC1-SE-011" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-200	DI-02	03	
SLUDGE COLLECTOR "FEC1-SE-011" HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-200	DI-02	04	
SLUDGE COLLECTOR "FEC1-SE-011" HIGH-HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-200	DI-02	05	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-02	06	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-02	07	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-02	08	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-02	09	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU3	OP-PLC-200	DI-02	10	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-02	11	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-02	12	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-02	13	
SLUDGE PUMP "FEC1-SLP-001" PFCC CONTACTOR CLOSED STATUS	OP-CP-LPU3	OP-PLC-200	DI-02	14	
SLUDGE PUMP "FEC1-SLP-001" PFCC OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-200	DI-02	15	
SLUDGE PUMP "FEC1-SLP-001" PFCC FAIL ALARM	OP-CP-LPU3	OP-PLC-200	DI-02	16	
SLUDGE PUMP "FEC1-SLP-001" SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-200	DI-03	01	
SLUDGE PUMP "FEC1-SLP-001" SELECTOR SWITCH REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-200	DI-03	02	
SLUDGE PUMP "FEC1-SLP-001" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-200	DI-03	03	
SLUDGE PUMP "FEC1-SLP-001" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-200	DI-03	04	
SLUDGE PUMP "FEC1-SLP-001" MOTOR OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-200	DI-03	05	
SLUDGE PUMP "FEC1-SLP-001" HIGH WINDING TEMPERATURE AUXILIARY RELAY STATUS	OP-CP-LPU3	OP-PLC-200	DI-03	06	
SLUDGE PUMP "FEC1-SLP-001" STATOR TEMPERATURE (DRY RUN PROTECTION)	OP-CP-LPU3	OP-PLC-200	DI-03	07	
SLUDGE PUMP "FEC1-SLP-001" HIGH-HIGH DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-200	DI-03	08	
SLUDGE PUMP "FEC1-SLP-001" LOW-LOW DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-200	DI-03	09	
SLUDGE PUMP "FEC1-SLP-001" LOCKOUT RELAY ALARM	OP-CP-LPU3	OP-PLC-200	DI-03	10	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-03	11	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-03	12	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-03	13	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-03	14	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-03	15	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-03	16	
SLUICE GATE "FEC1-SG-001" ACTUATOR SELECTOR SWITCH REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-200	DI-04	01	
SLUICE GATE "FEC1-SG-001" 100% OPENED STATUS	OP-CP-LPU3	OP-PLC-200	DI-04	02	
SLUICE GATE "FEC1-SG-001" 100% CLOSED STATUS	OP-CP-LPU3	OP-PLC-200	DI-04	03	
SLUICE GATE "FEC1-SG-001" ACTUATOR COMMON ALARM	OP-CP-LPU3	OP-PLC-200	DI-04	04	
SLUICE GATE "FEC1-SG-001" HIGH OPENING TORQUE ALARM	OP-CP-LPU3	OP-PLC-200	DI-04	05	
SLUICE GATE "FEC1-SG-001" HIGH CLOSING TORQUE ALARM	OP-CP-LPU3	OP-PLC-200	DI-04	06	
SLUICE GATE "FEC1-SG-001" FCS SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-200	DI-04	07	
SLUICE GATE "FEC1-SG-001" FCS SELECTOR SWITCH REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-200	DI-04	08	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-04	09	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-04	10	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-04	11	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-04	12	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-04	13	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU3	OP-PLC-200	DI-04	14	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-04	15	
SPARE	OP-CP-LPU3	OP-PLC-200	DI-04	16	
SLUDGE COLLECTOR "PTC1-SE-001" START COMMAND	OP-CP-LPU3	OP-PLC-200	DO-01	01	
SLUDGE COLLECTOR "PTC1-SE-001" STOP COMMAND	OP-CP-LPU3	OP-PLC-200	DO-01	02	
SPARE	OP-CP-LPU3	OP-PLC-200	DO-01	03	
SLUICE GATE "FEC1-SG-001" OPEN COMMAND	OP-CP-LPU3	OP-PLC-200	DO-01	04	
SLUICE GATE "FEC1-SG-001" CLOSE COMMAND	OP-CP-LPU3	OP-PLC-200	DO-01	05	
SLUICE GATE "FEC1-SG-001" STOP COMMAND	OP-CP-LPU3	OP-PLC-200	DO-01	06	
RAW WASTEWATER PUMP "RWP-1" START COMMAND	OP-CP-LPU3	OP-PLC-200	DO-01	07	
RAW WASTEWATER PUMP "RWP-1" STOP COMMAND	OP-CP-LPU3	OP-PLC-200	DO-01	08	
SLUDGE COLLECTOR "FEC1-SE-011" START COMMAND	OP-CP-LPU3	OP-PLC-200	DO-02	01	
SLUDGE COLLECTOR "FEC1-SE-011" STOP COMMAND	OP-CP-LPU3	OP-PLC-200	DO-02	02	
SPARE	OP-CP-LPU3	OP-PLC-200	DO-02	03	
SPARE	OP-CP-LPU3	OP-PLC-200	DO-02	04	
SPARE	OP-CP-LPU3	OP-PLC-200	DO-02	05	
SLUDGE PUMP "FEC1-SLP-001" START COMMAND	OP-CP-LPU3	OP-PLC-200	DO-02	06	
SLUDGE PUMP "FEC1-SLP-001" STOP COMMAND	OP-CP-LPU3	OP-PLC-200	DO-02	07	
SPARE	OP-CP-LPU3	OP-PLC-200	DO-02	08	
"FEC1-LIT-4211" FLOW EQUALIZATION BASIN NO. 1 LEVEL	OP-CP-LPU3	OP-PLC-300	AI-01	01	
"PTC1-LIT-4011" PTC1 PRIMARY BASIN NO. 1 SCUM PIT LEVEL	OP-CP-LPU3	OP-PLC-300	AI-01	02	
"FEC1-PIT-4111" PTC1 SCUM PUMP NO. 1 DISCHARGE PRESSURE	OP-CP-LPU3	OP-PLC-300	AI-01	03	
"PTC1-AE-1207-01B" HYDROGEN SULFIDE ANALYZING ELEMENT	OP-CP-LPU3	OP-PLC-300	AI-01	04	
"PTC1-AE-1208-01B" METHANE ANALYZING ELEMENT	OP-CP-LPU3	OP-PLC-300	AI-01	05	
SPARE	OP-CP-LPU3	OP-PLC-300	AI-01	06	
SPARE	OP-CP-LPU3	OP-PLC-300	AI-01	07	
SPARE	OP-CP-LPU3	OP-PLC-300	AI-01	08	
SLUDGE COLLECTOR "FEC1-SE-012" SELECTOR SWITCH AUTO POSITION STATUS	OP-CP-LPU3	OP-PLC-300	DI-01	01	
SLUDGE COLLECTOR "FEC1-SE-012" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-300	DI-01	02	
SLUDGE COLLECTOR "FEC1-SE-012" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-300	DI-01	03	
SLUDGE COLLECTOR "FEC1-SE-012" HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-300	DI-01	04	
SLUDGE COLLECTOR "FEC1-SE-012" HIGH-HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-300	DI-01	05	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-01	06	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-01	07	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-01	08	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-01	09	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU3	OP-PLC-300	DI-01	10	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-01	11	
RAW WASTEWATER PUMP "RWP-3" SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-300	DI-01	12	
RAW WASTEWATER PUMP "RWP-3" SELECTOR SWITCH REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-300	DI-01	13	
RAW WASTEWATER PUMP "RWP-3" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-300	DI-01	14	
RAW WASTEWATER PUMP "RWP-3" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-300	DI-01	15	
RAW WASTEWATER PUMP "RWP-3" RVSS FAULT ALARM	OP-CP-LPU3	OP-PLC-300	DI-01	16	
SCUM PUMP "FEC1-SCP-001" SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-300	DI-02	01	
SCUM PUMP "FEC1-SCP-001" SELECTOR SWITCH REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-300	DI-02	02	
SCUM PUMP "FEC1-SCP-001" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-300	DI-02	03	
SCUM PUMP "FEC1-SCP-001" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-300	DI-02	04	
SCUM PUMP "FEC1-SCP-001" MOTOR OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-300	DI-02	05	
SCUM PUMP "FEC1-SCP-001" HIGH WINDING TEMPERATURE AUXILIARY RELAY STATUS	OP-CP-LPU3	OP-PLC-300	DI-02	06	
SCUM PUMP "FEC1-SCP-001" STATOR TEMPERATURE (DRY RUN PROTECTION)	OP-CP-LPU3	OP-PLC-300	DI-02	07	
SCUM PUMP "FEC1-SCP-001" HIGH-HIGH DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-300	DI-02	08	
SCUM PUMP "FEC1-SCP-001" LOW-LOW DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-300	DI-02	09	
SCUM PUMP "FEC1-SCP-001" LOCKOUT RELAY ALARM	OP-CP-LPU3	OP-PLC-300	DI-02	10	
SCUM PUMP "FEC1-SCP-001" PFCC CONTACTOR CLOSED STATUS	OP-CP-LPU3	OP-PLC-300	DI-02	11	
SCUM PUMP "FEC1-SCP-001" PFCC OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-300	DI-02	12	
SCUM PUMP "FEC1-SCP-001" PFCC FAIL ALARM	OP-CP-LPU3	OP-PLC-300	DI-02	13	
SCUM PUMP "FEC1-SCP-001" LOW-LOW SCUM PIT LEVEL ALARM	OP-CP-LPU3	OP-PLC-300	DI-02	14	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-02	15	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-02	16	
MACERATOR "FEC1-MRT-001" MOTOR RUNNING FORWARD STATUS	OP-CP-LPU3	OP-PLC-300	DI-03	01	
MACERATOR "FEC1-MRT-001" MOTOR RUNNING REVERSE STATUS	OP-CP-LPU3	OP-PLC-300	DI-03	02	
MACERATOR "FEC1-MRT-001" COMMON ALARM	OP-CP-LPU3	OP-PLC-300	DI-03	03	
MACERATOR "FEC1-MRT-001" REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-300	DI-03	04	
MACERATOR "FEC1-MRT-001" MOTOR REMOTE CONTROL STATUS	OP-CP-LPU3	OP-PLC-300	DI-03	05	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	06	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	07	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	08	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	09	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	10	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	11	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	12	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	13	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	14	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	15	
SPARE	OP-CP-LPU3	OP-PLC-300	DI-03	16	
SLUDGE COLLECTOR "FEC1-SE-012" START COMMAND	OP-CP-LPU3	OP-PLC-300	DO-01	01	
SLUDGE COLLECTOR "FEC1-SE-012" STOP COMMAND	OP-CP-LPU3	OP-PLC-300	DO-01	02	
SPARE	OP-CP-LPU3	OP-PLC-300	DO-01	03	
SPARE	OP-CP-LPU3	OP-PLC-300	DO-01	04	
SPARE	OP-CP-LPU3	OP-PLC-300	DO-01	05	
SPARE	OP-CP-LPU3	OP-PLC-300	DO-01	06	
RAW WASTEWATER PUMP "RWP-3" START COMMAND	OP-CP-LPU3	OP-PLC-300	DO-01	07	
RAW WASTEWATER PUMP "RWP-3" STOP COMMAND	OP-CP-LPU3	OP-PLC-300	DO-01	08	
MACERATOR "FEC1-MRT-001" START COMMAND	OP-CP-LPU3	OP-PLC-300	DO-02	01	
MACERATOR "FEC1-MRT-001" STOP COMMAND	OP-CP-LPU3	OP-PLC-300	DO-02	02	
SPARE	OP-CP-LPU3	OP-PLC-300	DO-02	03	
SPARE	OP-CP-LPU3	OP-PLC-300	DO-02	04	
SPARE	OP-CP-LPU3	OP-PLC-300	DO-02	05	
SCUM PUMP "FEC1-SCP-001" START COMMAND	OP-CP-LPU3	OP-PLC-300	DO-02	06	
SCUM PUMP "FEC1-SCP-001" STOP COMMAND	OP-CP-LPU3	OP-PLC-300	DO-02	07	
SPARE	OP-CP-LPU3	OP-PLC-300	DO-02	08	
"PTC1-LIT-3721" PRIMARY CLARIFIER NO. 2 SLUDGE BLANKET LEVEL	OP-CP-LPU3	OP-PLC-400	AI-01	01	
"FEC1-LIT-4220" FLOW EQUALIZATION BASIN NO. 2 LEVEL	OP-CP-LPU3	OP-PLC-400	AI-01	02	
"FEC1-AIT-3822" PTC1 SLUDGE PUMP NO. 2 DISCHARGE SUSPENDED SOLIDS ANALYZER	OP-CP-LPU3	OP-PLC-400	AI-01	03	
SPARE	OP-CP-LPU3	OP-PLC-400	AI-01	04	
"FEC1-PIT-3821" PTC1 SLUDGE PUMP NO. 2 DISCHARGE PRESSURE	OP-CP-LPU3	OP-PLC-400	AI-01	05	
"OP-LIT-1675-02" RAW WASTEWATER WET WELL LEVEL - ULTRASONIC	OP-CP-LPU3	OP-PLC-400	AI-01	06	
SPARE	OP-CP-LPU3	OP-PLC-400	AI-01	07	
SPARE	OP-CP-LPU3	OP-PLC-400	AI-01	08	
SPARE	OP-CP-LPU3	OP-PLC-400	AO-01	01	
SPARE	OP-CP-LPU3	OP-PLC-400	AO-01	02	
SPARE	OP-CP-LPU3	OP-PLC-400	AO-01	03	
SPARE	OP-CP-LPU3	OP-PLC-400	AO-01	04	
SLUDGE COLLECTOR "PTC1-SE-002" SELECTOR SWITCH AUTO POSITION STATUS	OP-CP-LPU3	OP-PLC-400	DI-01	01	
SLUDGE COLLECTOR "PTC1-SE-002" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-400	DI-01	02	
SLUDGE COLLECTOR "PTC1-SE-002" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-400	DI-01	03	
SLUDGE COLLECTOR "PTC1-SE-002" HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-400	DI-01	04	
SLUDGE COLLECTOR "PTC1-SE-002" HIGH-HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-400	DI-01	05	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SPARE	OP-CP-LPU3	OP-PLC-400	DI-01	06	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-01	07	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-01	08	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-01	09	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-01	10	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-01	11	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-01	12	
RAW WASTEWATER WET WELL ULTRASONIC LOW LEVEL SHUT-OFF STATUS	OP-CP-LPU3	OP-PLC-400	DI-01	13	
RAW WASTEWATER PUMP "RWP-2" SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-400	DI-01	14	
RAW WASTEWATER PUMP "RWP-2" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-400	DI-01	15	
RAW WASTEWATER PUMP "RWP-2" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-400	DI-01	16	
SLUDGE COLLECTOR "FEC1-SE-021" SELECTOR SWITCH AUTO POSITION STATUS	OP-CP-LPU3	OP-PLC-400	DI-02	01	
SLUDGE COLLECTOR "FEC1-SE-021" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-400	DI-02	02	
SLUDGE COLLECTOR "FEC1-SE-021" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-400	DI-02	03	
SLUDGE COLLECTOR "FEC1-SE-021" HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-400	DI-02	04	
SLUDGE COLLECTOR "FEC1-SE-021" HIGH-HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-400	DI-02	05	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-02	06	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-02	07	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-02	08	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-02	09	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-02	10	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-02	11	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-02	12	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-02	13	
SLUDGE PUMP "FEC1-SLP-002" PFCC CONTACTOR CLOSED STATUS	OP-CP-LPU3	OP-PLC-400	DI-02	14	
SLUDGE PUMP "FEC1-SLP-002" PFCC OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-400	DI-02	15	
SLUDGE PUMP "FEC1-SLP-002" PFCC FAIL ALARM	OP-CP-LPU3	OP-PLC-400	DI-02	16	
SLUDGE PUMP "FEC1-SLP-002" SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-400	DI-03	01	
SLUDGE PUMP "FEC1-SLP-002" SELECTOR SWITCH REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-400	DI-03	02	
SLUDGE PUMP "FEC1-SLP-002" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-400	DI-03	03	
SLUDGE PUMP "FEC1-SLP-002" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-400	DI-03	04	
SLUDGE PUMP "FEC1-SLP-002" MOTOR OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-400	DI-03	05	
SLUDGE PUMP "FEC1-SLP-002" HIGH WINDING TEMPERATURE AUXILIARY RELAY STATUS	OP-CP-LPU3	OP-PLC-400	DI-03	06	
SLUDGE PUMP "FEC1-SLP-002" STATOR TEMPERATURE (DRY RUN PROTECTION)	OP-CP-LPU3	OP-PLC-400	DI-03	07	
SLUDGE PUMP "FEC1-SLP-002" HIGH-HIGH DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-400	DI-03	08	
SLUDGE PUMP "FEC1-SLP-002" LOW-LOW DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-400	DI-03	09	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SLUDGE PUMP "FEC1-SLP-002" LOCKOUT RELAY ALARM	OP-CP-LPU3	OP-PLC-400	DI-03	10	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-03	11	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-03	12	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-03	13	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-03	14	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-03	15	
SPARE	OP-CP-LPU3	OP-PLC-400	DI-03	16	
SLUDGE COLLECTOR "PTC1-SE-002" START COMMAND	OP-CP-LPU3	OP-PLC-400	DO-01	01	
SLUDGE COLLECTOR "PTC1-SE-002" STOP COMMAND	OP-CP-LPU3	OP-PLC-400	DO-01	02	
SPARE	OP-CP-LPU3	OP-PLC-400	DO-01	03	
SPARE	OP-CP-LPU3	OP-PLC-400	DO-01	04	
SPARE	OP-CP-LPU3	OP-PLC-400	DO-01	05	
SPARE	OP-CP-LPU3	OP-PLC-400	DO-01	06	
RAW WASTEWATER PUMP "RWP-2" START COMMAND	OP-CP-LPU3	OP-PLC-400	DO-01	07	
RAW WASTEWATER PUMP "RWP-2" STOP COMMAND	OP-CP-LPU3	OP-PLC-400	DO-01	08	
SLUDGE COLLECTOR "FEC1-SE-021" START COMMAND	OP-CP-LPU3	OP-PLC-400	DO-02	01	
SLUDGE COLLECTOR "FEC1-SE-021" STOP COMMAND	OP-CP-LPU3	OP-PLC-400	DO-02	02	
SPARE	OP-CP-LPU3	OP-PLC-400	DO-02	03	
SPARE	OP-CP-LPU3	OP-PLC-400	DO-02	04	
SPARE	OP-CP-LPU3	OP-PLC-400	DO-02	05	
SLUDGE PUMP "FEC1-SLP-002" START COMMAND	OP-CP-LPU3	OP-PLC-400	DO-02	06	
SLUDGE PUMP "FEC1-SLP-002" STOP COMMAND	OP-CP-LPU3	OP-PLC-400	DO-02	07	
SPARE	OP-CP-LPU3	OP-PLC-400	DO-02	08	
"FEC1-LIT-4221" FLOW EQUALIZATION BASIN NO. 2 LEVEL	OP-CP-LPU3	OP-PLC-500	AI-01	01	
"PTC1-LIT-4021" PTC1 PRIMARY BASIN NO. 2 SCUM PIT LEVEL	OP-CP-LPU3	OP-PLC-500	AI-01	02	
"FEC1-PIT-4121" PTC1 SCUM PUMP NO. 2 DISCHARGE PRESSURE	OP-CP-LPU3	OP-PLC-500	AI-01	03	
"FEC1-AIT-3832" PTC1 SLUDGE PUMP NO. 3 DISCHARGE SUSPENDED SOLIDS ANALYZER	OP-CP-LPU3	OP-PLC-500	AI-01	04	
SPARE	OP-CP-LPU3	OP-PLC-500	AI-01	05	
"FEC1-PIT-3831" PTC1 SLUDGE PUMP NO. 3 DISCHARGE PRESSURE	OP-CP-LPU3	OP-PLC-500	AI-01	06	
"PTC1-AE-1207-01C" HYDROGEN SULFIDE ANALYZING ELEMENT	OP-CP-LPU3	OP-PLC-500	AI-01	07	
"PTC1-AE-1208-01C" METHANE ANALYZING ELEMENT	OP-CP-LPU3	OP-PLC-500	AI-01	08	
SPARE	OP-CP-LPU3	OP-PLC-500	AO-01	01	
SPARE	OP-CP-LPU3	OP-PLC-500	AO-01	02	
SPARE	OP-CP-LPU3	OP-PLC-500	AO-01	03	
SPARE	OP-CP-LPU3	OP-PLC-500	AO-01	04	
SLUDGE COLLECTOR "FEC1-SE-022" SELECTOR SWITCH AUTO POSITION STATUS	OP-CP-LPU3	OP-PLC-500	DI-01	01	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SLUDGE COLLECTOR "FEC1-SE-022" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-500	DI-01	02	
SLUDGE COLLECTOR "FEC1-SE-022" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-500	DI-01	03	
SLUDGE COLLECTOR "FEC1-SE-022" HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-500	DI-01	04	
SLUDGE COLLECTOR "FEC1-SE-022" HIGH-HIGH TORQUE ALARM	OP-CP-LPU3	OP-PLC-500	DI-01	05	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-01	06	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-01	07	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-01	08	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-01	09	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-01	10	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-01	11	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-01	12	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-01	13	
SLUDGE PUMP "FEC1-SLP-003" PFCC CONTACTOR CLOSED STATUS	OP-CP-LPU3	OP-PLC-500	DI-01	14	
SLUDGE PUMP "FEC1-SLP-003" PFCC OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-500	DI-01	15	
SLUDGE PUMP "FEC1-SLP-003" PFCC FAIL ALARM	OP-CP-LPU3	OP-PLC-500	DI-01	16	
SLUDGE PUMP "FEC1-SLP-003" SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-500	DI-02	01	
SLUDGE PUMP "FEC1-SLP-003" SELECTOR SWITCH REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-500	DI-02	02	
SLUDGE PUMP "FEC1-SLP-003" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-500	DI-02	03	
SLUDGE PUMP "FEC1-SLP-003" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-500	DI-02	04	
SLUDGE PUMP "FEC1-SLP-003" MOTOR OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-500	DI-02	05	
SLUDGE PUMP "FEC1-SLP-003" HIGH WINDING TEMPERATURE AUXILIARY RELAY STATUS	OP-CP-LPU3	OP-PLC-500	DI-02	06	
SLUDGE PUMP "FEC1-SLP-003" STATOR TEMPERATURE (DRY RUN PROTECTION)	OP-CP-LPU3	OP-PLC-500	DI-02	07	
SLUDGE PUMP "FEC1-SLP-003" HIGH-HIGH DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-500	DI-02	08	
SLUDGE PUMP "FEC1-SLP-003" LOW-LOW DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-500	DI-02	09	
SLUDGE PUMP "FEC1-SLP-003" LOCKOUT RELAY ALARM	OP-CP-LPU3	OP-PLC-500	DI-02	10	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-02	11	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-02	12	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-02	13	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-02	14	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-02	15	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-02	16	
SCUM PUMP "FEC1-SCP-002" SELECTOR SWITCH LOCAL POSITION STATUS	OP-CP-LPU3	OP-PLC-500	DI-03	01	
SCUM PUMP "FEC1-SCP-002" SELECTOR SWITCH REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-500	DI-03	02	
SCUM PUMP "FEC1-SCP-002" MOTOR CONTROL RELAY STATUS	OP-CP-LPU3	OP-PLC-500	DI-03	03	
SCUM PUMP "FEC1-SCP-002" MOTOR RUNNING STATUS	OP-CP-LPU3	OP-PLC-500	DI-03	04	
SCUM PUMP "FEC1-SCP-002" MOTOR OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-500	DI-03	05	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
SCUM PUMP "FEC1-SCP-002" HIGH WINDING TEMPERATURE AUXILIARY RELAY STATUS	OP-CP-LPU3	OP-PLC-500	DI-03	06	
SCUM PUMP "FEC1-SCP-002" STATOR TEMPERATURE (DRY RUN PROTECTION)	OP-CP-LPU3	OP-PLC-500	DI-03	07	
SCUM PUMP "FEC1-SCP-002" HIGH-HIGH DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-500	DI-03	08	
SCUM PUMP "FEC1-SCP-002" LOW-LOW DISCHARGE PRESSURE ALARM	OP-CP-LPU3	OP-PLC-500	DI-03	09	
SCUM PUMP "FEC1-SCP-002" LOCKOUT RELAY ALARM	OP-CP-LPU3	OP-PLC-500	DI-03	10	
SCUM PUMP "FEC1-SCP-002" PFCC CONTACTOR CLOSED STATUS	OP-CP-LPU3	OP-PLC-500	DI-03	11	
SCUM PUMP "FEC1-SCP-002" PFCC OVERLOAD ALARM	OP-CP-LPU3	OP-PLC-500	DI-03	12	
SCUM PUMP "FEC1-SCP-002" PFCC FAIL ALARM	OP-CP-LPU3	OP-PLC-500	DI-03	13	
SCUM PUMP "FEC1-SCP-002" LOW-LOW SCUM PIT LEVEL ALARM	OP-CP-LPU3	OP-PLC-500	DI-03	14	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-03	15	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-03	16	
MACERATOR "FEC1-MRT-002" MOTOR RUNNING FORWARD STATUS	OP-CP-LPU3	OP-PLC-500	DI-04	01	
MACERATOR "FEC1-MRT-002" MOTOR RUNNING REVERSE STATUS	OP-CP-LPU3	OP-PLC-500	DI-04	02	
MACERATOR "FEC1-MRT-002" COMMON ALARM	OP-CP-LPU3	OP-PLC-500	DI-04	03	
MACERATOR "FEC1-MRT-002" REMOTE POSITION STATUS	OP-CP-LPU3	OP-PLC-500	DI-04	04	
MACERATOR "FEC1-MRT-002" MOTOR REMOTE CONTROL STATUS	OP-CP-LPU3	OP-PLC-500	DI-04	05	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	06	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	07	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	08	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	09	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	10	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	11	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	12	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	13	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	14	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	15	
SPARE	OP-CP-LPU3	OP-PLC-500	DI-04	16	
SLUDGE COLLECTOR "FEC1-SE-022" START COMMAND	OP-CP-LPU3	OP-PLC-500	DO-01	01	
SLUDGE COLLECTOR "FEC1-SE-022" STOP COMMAND	OP-CP-LPU3	OP-PLC-500	DO-01	02	
SPARE	OP-CP-LPU3	OP-PLC-500	DO-01	03	
SPARE	OP-CP-LPU3	OP-PLC-500	DO-01	04	
SPARE	OP-CP-LPU3	OP-PLC-500	DO-01	05	
SLUDGE PUMP "FEC1-SLP-003" START COMMAND	OP-CP-LPU3	OP-PLC-500	DO-01	06	
SLUDGE PUMP "FEC1-SLP-003" STOP COMMAND	OP-CP-LPU3	OP-PLC-500	DO-01	07	
SPARE	OP-CP-LPU3	OP-PLC-500	DO-01	08	
MACERATOR "FEC1-MRT-002" START COMMAND	OP-CP-LPU3	OP-PLC-500	DO-02	01	

OPERATIONS BUILDING

DESCRIPTION	PANEL	RACK	MODULE	PT.	EXISTING
MACERATOR "FEC1-MRT-002" STOP COMMAND	OP-CP-LPU3	OP-PLC-500	DO-02	02	
SPARE	OP-CP-LPU3	OP-PLC-500	DO-02	03	
SPARE	OP-CP-LPU3	OP-PLC-500	DO-02	04	
SPARE	OP-CP-LPU3	OP-PLC-500	DO-02	05	
SCUM PUMP "FEC1-SCP-002" START COMMAND	OP-CP-LPU3	OP-PLC-500	DO-02	06	
SCUM PUMP "FEC1-SCP-002" STOP COMMAND	OP-CP-LPU3	OP-PLC-500	DO-02	07	
SPARE	OP-CP-LPU3	OP-PLC-500	DO-02	08	