VOLUME 2 OF 2

S P E C I F I C A T I O N S

FOR

NORTHERN KENTUCKY WATER DISTRICT

TAYLOR MILL
WATER TREATMENT PLANT
ADVANCED TREATMENT
IMPROVEMENTS
(Project No. 184-457)

March 2011

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NORTHERN KENTUCKY WATER DISTRICT

TAYLOR MILL WATER TREATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS

PROJECT MANUAL VOLUME 2 OF 2

PROJECT NO. 184-457

CERTIFICATIONS

Certification of the Engineers of Record

I hereby certify these documents were prepared by me, or under my direct personal supervision, and I am a duly Licensed Professional Engineer under the laws of the State of the Commonwealth of Kentucky.

MALCOLM PIRNIE INC.
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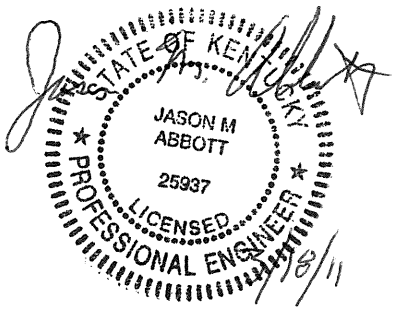
KY PE Number: 25937



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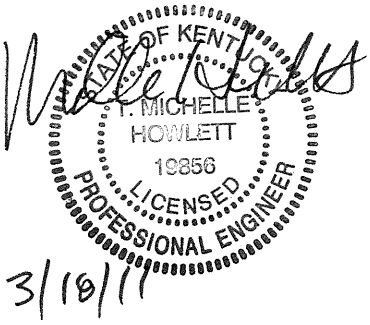

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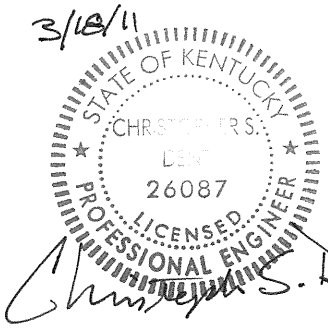

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SECTION 11110

VERTICAL LINESHAFT PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified and required to furnish and install vertical lineshaft pumps complete and operational.
   2. Included are pump, motor, coupling, base, drive, pre-lubrication, and anchorage systems and all appurtenances.
   3 Variable Frequency Drive (VFD) units shall be furnished by the CONTRACTOR in accordance with the Bid Form and specification Section 16446, Variable Frequency Drives, requirements.
   4. CONTRACTOR and pump manufacturer shall assume full responsibility for the completeness of the pumping units. CONTRACTOR shall obtain the motors for pumps from a single manufacturer. Pump manufacturer shall coordinate with the motor manufacturer and variable frequency drive (VFD) manufacturer to ensure that the starting, accelerating and operating torques of the motor and VFD are sufficient to start and operate the pump over the specified speed range.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before vertical lineshaft pump Work.

C. Related Sections:
   1. Section 03600, Precision Grouting
   2. Section 05500 Metal Fabricating.
   3. Section 09910, Painting.
   4. Section 13420, Primary Sensors and Field Instruments.
   5. Division 16, Electrical and Electrical Contract Drawings.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. American Bearing Manufacturers Association (ABMA).
   2. American National Standards Institute (ANSI).
   3. ASTM A48/A48M, Specification for Grey Iron Castings.
   4. American Water Works Association (AWWA).
   5. ANSI/HI 2.3, Vertical Pumps for Design and Application.

6. ANSI/HI 2.4, Vertical Pumps for Installation, Operation, and Maintenance
7. ANSI/HI 2.6, Vertical Pump Tests
8. ANSI/HI 9.1-9.5, Pumps – General Guidelines.
9. ANSI/HI 9.6.2, Centrifugal and Vertical Pumps for Allowable Nozzle Loads
10. ANSI/HI 9.6.4, Centrifugal and Vertical Pumps for Vibration Measurements and Allowable Values.
11. ANSI/HI 9.6.5, Centrifugal and Vertical Pumps for Condition Monitoring
12. ANSI/HI 9.8, Pump Intake Design.
13. ANSI/NSF 61 Drinking Water Components – Health Effects
14. AWWA E103 Horizontal and Vertical Line-Shaft Pumps
15. AWS D1.1/D1.1M, Structural Welding Code-Steel.
16. IEEE 85, Airborne Sound Measurements- Rotating Electrical Machinery.
17. National Electrical Manufacturers' Association (NEMA).

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience producing substantially similar equipment to that specified in this Section and shall be able to document at least five installations in satisfactory operation for at least five years.

B. Welding Qualifications: Equipment manufacturer's shop welds and welding procedures and personnel shall be qualified and certified per AWS D1.1/D1.1M.

C. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of component manufacturer from a single vertical lineshaft pump manufacturer.
   2. The equipment manufacturer shall prepare, or review and approve all Shop Drawings and other submittals for components furnished under this Section.
   3. Components shall be specifically constructed for specified service conditions and be integrated into overall assembly by vertical lineshaft pump manufacturer.

D. Certifications
   1. Certification of Compliance:
      a. Obtain certification of compliance with the Contract Documents from the vertical lineshaft pump manufacturer on manufacturer letterhead; certification by manufacturer's representatives is not acceptable.
      b. Certification shall be worded as follows:
      "[*Insert manufacturer's name*] proposes to supply equipment included in Section 11110, Vertical Lineshaft Pumps for the Northern Kentucky Water District, Taylor Mill, Kentucky, Taylor Mill Water Treatment Plant Advanced Treatment Improvements. We have examined the Contract Documents and understand of the Project requirements insofar as they affect the proposed products. We certify that the products will operate satisfactorily under the conditions described in the Contract Documents

and that the products meet the requirements of the Contract Documents:

[*List exceptions, deviations or changes necessary or recommended to accommodate the proposed products.]*

We further certify that the products to be furnished shall conform to the standards listed in Section 11110, Vertical Lineshaft Pumps, of the Contract Documents.

[*List exceptions, deviations or changes necessary or recommended to accommodate the proposed products.]*

_____ _____

Authorized Signature & Title Date"

c. Provide justification for exceptions, variations, deviations, or changes. ENGINEER will determine whether exceptions, deviations, and changes are acceptable. Exceptions, variations, deviations, and changes may result in rejection of products.
d. Provide certification before submitting Shop Drawings. Shop Drawings will not be reviewed prior to receipt of certification.
e. Acceptance of certification shall not relieve CONTRACTOR of responsibility for adequacy of all products.
f. Submittal of certification shall not relieve CONTRACTOR, equipment manufacturer, and Supplier of requirement to comply with Submittal procedures in the Contract Documents.

1.4 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings: Submit the following:
      a. Manufacturer's literature, illustrations, specifications, paint certification and engineering data including; dimensions, materials, size, weight. and part lists for all components in sufficient detail to allow an item by item comparison with the Contract Documents.
      b. Performance data and curves showing overall pump efficiencies, required net positive suction head, allowable suction lift, flow rate, head, brake horsepower, motor horsepower, speed, and shut-off head. Curves shall range from minimum flow to shut-off head at for full speed and all speed curves specified. For variable speed units, curves shall have at least five speeds plotted between maximum and minimum rpm. Provide data on pump head losses to include entrance, bowl, column, and discharge head losses
      c. Drawings of the products, including fabrication methods, assembly, accessories, installation details, dimensions, and wiring diagrams.

d. Minimum submergence required over suction bell at minimum head listed in service conditions in Part 2 of this Section.
e. Curve of down-thrust versus capacity for the entire range of operation from shutoff to minimum head conditions.
f. Upthrust at starting.
g. Wr^2 of pump.
h. For Project with required efficiency guarantees by pump manufacturer, provide a statement regarding compliance with the specified bowl efficiency and guaranteed wire-to-water efficiency for each pump/motor combination at design point listed in the service conditions in Part 2 of this Section.
i. Impeller diameter.
j. Location of nearest permanent service headquarters of pump manufacturer to the Site.
k. Paint color samples for finish on pumps and motors. Color samples shall conform to Section 09910, Painting.
l. Analysis and calculations by a qualified specialist for critical speed of pump and motor shaft.
m. Motor test reports per the requirements of Section 16220, Motors.
n. Provide a copy of the manufacturer's standard warranty for parts and labor.
o. Proposed shop test procedures and field test procedures, and location of the shop tests.

B. Informational Submittals:
1. Certificates:
a. Provide certification of compliance as specified in this Section.
b. Provide welding certifications.
2. Test Reports: Submit written reports of:
a. Shop tests. Provide prior to shipmen from factory.
b. Field operating tests.
3. Manufacturer's Instructions: Submit manufacturer's instructions and recommendations for:
a. Storage.
b. Handling.
c. Setting drawings, templates, and directions for installing anchor bolts and other anchorages.
d. Installation.
4. Manufacturer's Reports: Submit a written report of the results of each visit by a manufacturer's serviceman, including purpose and time of visit, tasks performed and results obtained.
5. Qualifications Data: Submit qualifications data as specified in this Section.

C. Closeout Submittals:
1. Operation and Maintenance Data:
a. Submit complete operation and maintenance manuals, including copies of

test reports, maintenance data, and schedules, description of operation, and spare parts information.

b. Furnish operation and maintenance manuals per Section 01781, Operation and Maintenance Data.

2. Tools and Spare Parts: Provide tools and spare parts as specified in this Section:

1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:

1. Prior to shipping, completely inspect products to assure that components are complete and comply with all requirements. Box or crate products as required to prevent damage during shipment. Protect machined surfaces and matching connections to prevent damage.
2. Deliver products to Site to ensure uninterrupted progress of the Work. Deliver anchorage products that are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work.
3. Inspect all boxes, crates, and packages upon delivery to Site and notify ENGINEER in writing of loss or damage to products. Promptly remedy loss and damage to new condition per manufacturer's instructions.
4. Conform to Section 01651, Transportation and Handling of Products.

B. Storage and Protection:

1. Keep all products off ground using pallets, platforms, or other supports. Protect steel, packaged materials, and electronics from corrosion and deterioration.
2. Conform to Section 01661, Storage and Protection of Products.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Equipment: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.7 SPARE PARTS

A. Special Tools: Furnish two sets of special tools required for normal operation and maintenance of products furnished.

B. Extra Materials:

1. Furnish the following spare parts for each vertical lineshaft pump furnished under the Contract:
   a. Complete set of gaskets and packing.
   b. One set of sleeve bearings for shafting.

c. One set of wear rings for each impeller on pump
d. One year's supply of lubricants required for pump and bearings.
e. Complete set of fasteners, bolts, nuts, pins, keys, and washers that are not of standard manufacture.

2. Furnish and deliver spare parts carefully packed in sturdy containers with clear indelible identification markings. Store spare parts as recommended by manufacturer until transferred to OWNER.
3. Product manufacturer shall provide a list of additional recommended spare parts for an operating period of one year. List shall describe each part, quantity recommended, and manufacturer's standard unit price for the part.

PART 2 - PRODUCTS

2.1 SERVICE CONDITIONS

A. Description: Equipment provided shall be suitable for process and service conditions specified in the Contract Documents and shall conform to ANSI/HI 2.3. Pumps shall be designed, constructed, and installed for service intended and shall comply with the service conditions listed below.

B. Pump's characteristic curve shall rise continuously from minimum head condition to shutoff without dips. Complete pumping unit, consisting of suction/intake, bowl(s), column, pump head, motor, and appurtenances shall be suitable in all respects for continuous, stable performance when operating at each point on pump's characteristic curve, without cavitation and in accordance with vibration criteria specified herein.

C. Each complete pumping unit with motor shall be capable of safely operating at up to 125 percent of full load speed in reverse rotation without sustaining damage.

D. Head conditions specified are those required at discharge head outlet. Pump losses, i.e. column, discharge head, and entrance losses are not included and shall be added by manufacturer to this value for total required pump head.

E. Performance Criteria:
1. Pumps shall comply with the following minimum conditions:

Design Conditions	**GAC Feed Pump No. 1**	**GAC Feed Pump No. 2**	**GAC Feed Pump No. 3**
Location	GAC Feed Pump Station		
Use	GAC Supply		
Fluid Pumped	Post Filter Water		
Number of Stages per Pump	2	2	2
* Design Flow (1st design point) (gpm)	4,167	4,167	4,167
* Design Total Head (1st	60	60	60

Design Conditions	GAC Feed Pump No. 1	GAC Feed Pump No. 2	GAC Feed Pump No. 3
design point) (ft)			
Minimum Bowl Efficiency at Design (1st design point) (percent)	83	83	83
* Design Flow (2nd design point, 2 pumps operating in parallel) (gpm)	8,333	8,333	8,333
* Design Total Head (2nd design point, 2 pumps operating in parallel) (ft)	74	74	74
Minimum Bowl Efficiency at Design (2nd design point, 2 pumps operating in parallel)	80	80	80
**Motor (Hp)	100	100	100
Max Operating Speed (rpm)	1200	1200	1200
Pump Column Diameter (in)	14	14	14
Discharge Nozzle Dia. (in)	14	14	14
** Available NPSH at Design (1st design point) (ft)	43	43	43
Head at Zero Flow (ft)	122	122	122
Type of Lubrication (water or oil)	Water	Water	Water
Maximum Liquid Elev. in Suction Well (ft)	521.5	521.5	521.5
Minimum Liquid Elev. in Suction Well (ft)	515.0	515.0	515.0
Elevation of Suction Well Floor (ft)	509.0	509.0	509.0
Pump Discharge Centerline Elevation (ft.)	527.0	527.0	527.0
Fluid Temperature (degrees F)	34-90	34-90	34-90
Fluid pH	7-9	7-9	7-9
Drive Type	VFD	VFD	VFD
**** Motor Size (hp)	100	100	100
Motor Voltage/Phase/Hertz	460V/3PH/60HZ		

* At maximum speed. Does not include entrance, pump, column, and discharge head losses.

** Required NPSH shall be for size impeller furnished. If impeller is trimmed, provide the curve The impeller as trimmed.

*** Flow at the 2nd Design Point total head shall be within ten percent of value specified.

**** Pump horsepower requirements shall not exceed stated horsepower at all points on pump curve.

2.2 MANUFACTURERS

A. Manufacturers:
   1. Provide vertical lineshaft pumps of one of the following:
      a. Peerless Pump.
      b. Goulds Pumps.

c. Floway Pumps.
d. Or equal.

2. Provide motors manufactured by one of the following:
   a. U.S. Motors.
   b. General Electric.
   c. Or equal.

2.3 DETAILS OF CONSTRUCTION

A. Pump Materials and Construction:

1. Pump and wetted components of pumps conveying potable water or water that will be treated to become potable shall conform to ANSI.
2. Pump Base: Provide base of high-grade cast-iron or fabricated steel for mounting driver and supporting pump column. Surface discharge outlet shall be flanged. Flanges shall be ANSI B16.1, Class 125.
3. Pump Bowls: Castings shall be of close-grained cast-iron smooth and free of casting imperfections, conforming to ASTM A48/A48M. Bowls shall have Bronze replicable wear rings
4. Impellers: Impellers shall be Bronze of enclosed type, statically and dynamically balanced. Securely fasten impeller to shaft with keys, taper bushings, or lock nuts. Impellers shall be adjustable vertically by means of a nut in driver. Each impeller shall be supplied with a Bronze replacable wear ring.
5. Pump Shafts: Shall be stainless steel not less than 12 percent chromium, heat-treated, ground, and polished. Shaft diameter shall be sized for total axial thrust, torque and weight of all rotating parts supported by shaft and horsepower transmitted. Maximum combined shear stress shall not exceed 30 percent of elastic limit in tension or be more than 18 percent of ultimate tensile strength of shafting material.
6. Line Shafts: Line shafts shall be of 416 series stainless steel. Surface finish shall not exceed RMS 40. Line shafts shall be furnished in lengths not greater than five feet with ends faced squarely for perfect alignment after installation. Shafting shall be coupled with 410 Stainless Steel couplings, designed with a safety factor of 1.5 times shaft safety factor and be left-hand thread to tighten during pump operation. Couplings shall be prevented from unscrewing when a 125% backspin occurs.
7. Line Shaft Bearings: Line shaft bearings shall be water lubricated and mounted in bearing retainers held in position in column couplings by means of butted ends of column pipes. Bearing retainers shall be locked into position against rotation within the column. Locate bearings at intervals of no more than five feet.
8. Discharge Column Pipe: Flanged column pipe shall be standard inside diameter, with minimum size as noted in paragraph 2.1. Pipe shall be furnished in sections of nominal five-foot lengths and be interchangeable. Friction pipe loss shall not exceed five feet of head per 100 feet of length, at pump's rated capacity.
9. Discharge Head Assembly: Provide discharge head assembly with a shaft-packing box. Steel shafting passing through packing boxes shall be stainless

steel. Head shaft shall be suitable for reversing ends to renew stuffing box wearing surface.

a. Provide water-flushed mechanical seal type as specified below:
   1) John Crane, Type 5610; Chesterton 155; or equal.
   2) Seal face material to be Silicon Carbide vs. Silicon Carbide.
   3) Rotating metal parts shall be Type 316 stainless steel.
   4) O-rings for mechanical seals shall be EPDM, or equal.
   5) Provide Type L copper piping to convey seal leakage to approved drain location.

10. Provide removable, adjustable, water slinger fitted to pump shaft to prevent pressurized leakage from stuffing box from entering motor enclosure.
11. Vortex breaker:
    a. For each GAC Feed Pump, proved a 316 SS vortex suppressor, mechanically attached to the suction bell of the bowl assembly, complete with a hydrocone as part of the vortex suppressor. Standard basket strainers are not considered equal and are not acceptable.
12. Provide anchorages and inserts under this Section. Anchorages and inserts shall be sized and installed per pump manufacturer's recommendations.
13. Bolts, nuts, and cap screws shall have hexagon heads.
14. Attach to pump brass or stainless steel nameplates giving manufacturer's name, model, and serial number, pump rated capacity, head, speed and other pertinent data.

B. Motors: Motors shall be provided in accordance with Section 16220, Motors, and shall comply with the minimum size and voltage ratings specified in paragraph 2.1. and shall have the following monitoring instruments(sensors):.
   1. Vibration and Temperature Detectors:
      a. 3-Axis vibration and temperature MeMs based accelerometer. Dynamic range of +/-6G and 5-3500 Hz.
      b. Three (one each phase) positioned to detect highest winding temperature and located between coil sides in stator slots.
      c. Compatible with monitoring instrumentation as specified in 2.4.
      d. Leads brought to separate motor terminal box.
      e. Unit to be ITT Model ITT VT-03.
   2. Bearing Temperature Protection:
      a. On the thrust bearing of each motor.
   3. Bearing Temperature Transducer:
      a. Pump motor bearing and windings temperature sensors shall be permanently installed by motor manufacturer.
      b. Monitoring system shall include four (4) temperature inputs.
   4. Motor Casting Velocity Transducer.
   5. Radial Vibration Transducer:
      a. Consisting of proximity probe, calibrated extension cable, and connector.
      b. Elements shall be fully protected in sealed weatherproof conduit and housing.

c. For pump motor with sleeve bearings, radial shaft displacement proximity probe shall be permanently installed by motor manufacturer.
d. Mount probes at 90 degrees radially from one another.

2.4 CONTROLS

A. Provide variable frequency drive (VFD) with the following features and in accordance with Section 16446, Variable Frequency Drives:
1. VFD shall be housed in a free standing NEMA 12 rated painted steel enclosure constructed in accordance with Section 13430, Panels and Enclosures and Section 13440 Panel Instruments and Devices.
2. Although all required signals for operation will be hardwired, VFD shall have the capability to communicate via Ethernet/IP for additional monitoring of parameters.
3. Provide the following front panel devices on the control panel:
a. Low level white LED push-to-test indicating light.
b. In remote white LED push-to-test indicating light.
c. Motor high temperature amber LED push-to-test indicating light.
d. VFD fault amber LED push-to-test indicating light.
e. Monitoring system fault amber LED push-to-test indicating light.
f. Running green LED push-to-test indicating light.
g. High discharge pressure amber LED push-to-test indicating light.
h. Elapsed run time indicating meter
i. VFD/PLC selector switch
j. Start pushbutton
k. Stop pushbutton
l. Speed setpoint potentiometer
m. Human machine interface (HIM) keypad
4. Provide the following inputs to the system:
a. Discrete inputs:
1) Low level pump cutoff (N.C.) (from float switch).
2) Start/stop signal (from plant PLC)
3) High discharge pressure (from pressure switch)
4) In remote (from LCS selector switch)
5) Start/stop signal (from LCS start and stop pushbutton)
b. Analog inputs:
1)Speed setpoint (from plant PLC)
5. Provide the following outputs to the system:
a. Discrete outputs:
1) Common fault (to LCS indicating light)
2) Running (to LCS indicating light and monitoring system)
3) High pressure (to plant PLC)
4) Monitoring system fault (to plant PLC)
5) VFD Fault (to plant PLC)
6) In Remote (to plant PLC)
7) Running (to plant PLC)

b. Analog outputs:
    1. Speed feedback (to plant PLC)
    2. Speed feedback (to monitoring system in LCS
6. Functional Description
    a. Local control:
        1) When the local-off-remote (LOR) selector switch at the local control station (LCS) is in the local position, the pump shall be operated by the start and stop pushbuttons at the local control station. The speed shall be adjusted by the potentiometer at the VFD.
        2) When the LOR selector switch at the LCS is in the off position, the pump shall not run.
    b. Remote Control
        1) When the LOR selector switch at the LCS is in the remote position and the VFD/PLC selector switch at the VFD is in the VFD position, the pump shall be operated from the start and stop pushbuttons at the VFD. The speed shall be adjusted by the potentiometer at at VFD.
        2) When the LOR selector switch at the LCS is in the remote position and the VFD/PLC selector switch at the VFD is in the PLC position, the pump shall be operated from the start and stop input to the VFD. The speed shall be adjusted by the speed setpoint signal.
    c. Upon receiving any of the following inputs, the system shall shutdown, latch the alarm (unless otherwise indicated), illuminate the appropriate indicating light, and close the dry contact output. Upon clearing the alarm condition and resetting the system via the reset pushbutton, the system shall be ready again for operation
        1) High discharge pressure
        2) Monitoring system fault
        3) Wet well low level (do not latch)
        4) FD Fault

B. Vibration, Temperature, and Monitoring System:
    1. General:
        a. Provide temperature and vibration monitoring systems in cabinet as shown in Process and Instrumentation Diagram (P&ID), program, test, calibrate, fully configure and place into operation. Vibration and temperature monitoring system shall be connected to and coordinated with the plant SCADA System.
    2. Monitoring System Functionality:
        a. The online monitoring system shall be capable of measuring, collecting, archiving, and displaying machine health data. The system shall be employed for the purpose of predictive maintenance planning and immediate retrieval of live data when required. Live data is defined as any data collected in the past 10 minutes.
        b. Machine health data shall be collected by permanently mounted sensors.
        c. The data collected shall be available for display anywhere in the world via internet connection for users with proper login credentials (user ID and

password). The loading of software to a PC for purposes of viewing the archived data is unacceptable. The only software needed shall be a web-browser.

d. The online condition monitoring system shall be suitable for use on any machine with a rotating shaft.

e. The system shall generally consist of the following items:
   1) Sensors: Measure data on monitored machine.
   2) Data Monitors: Collect data located at or near the machine and then wirelessly transmit data through ratios up to a communication module/internet gateway.
   3) Communication Module/Internet Gateway: Collects local data from data monitors (up to 50) and relays information up to an Internet server, managed by manufacturer, via the Internet connection.
   4) Graphical User Interface (GUI): Internet accessed, using a standard web browser. Displays archived and live data allows for manipulation of alarm and warning settings. The graphical user interface also serves to remotely configure and set up the system.

f. The online conditioning monitoring system shall be designed such that the only communication cables required are between the sensors and the data monitor. Communication between the monitored machine and the communication module shall be wireless. The communication to the Internet shall be available, at a minimum, through a cell modem and through a wired Ethernet connection (compatible with DHCP and static IP).

g. The architecture shall be a star topology and point-to-point communication. It shall be able to handle up to 30 data monitors with one communication module when radio communication in the environment allows.

h. The system shall employ user selectable warning and alarm settings for each data channel. Warnings and alarms shall be annunciated to the GUI, DM status LEDs, local relay, and user defined email notifications.

i. Archived and live vibration spectral data or also known as Fast Fourier Transforms (FFT) shall be available on demand, schedule, and on alarm through the GUI. The FFTs shall be available in at least 1000 lines of resolution for scheduled and alarm triggered FFTs or at least 4000 lines of resolution for user requested FFTs.

j. Time-waveform data (TWF) shall be available with user requested FFTs. The GUI shall display FFT data, TWF data, or both.

3. Monitoring System Components:

   a. Sensors: These sensors shall be available as required by the monitored machine.
      1) Vibration: Each vibration sensor shall be capable of measuring machine vibration in the X, Y, and Z axes. The vibration sensors shall be of (3) three axis design. Sensors with only (1) one or (2) two axes are not acceptable. Each vibration sensors shall also have an integrated temperature sensor.

a) Operational Temperature Range: -40 degrees F to 185 degrees F.
b) Frequency Range (X, Y, Z): 6 Hz to 4000 Hz.
c) Vibration Reading Accuracy: +/- 10 percent.

2) Temperature: Temperature sensors shall be integral to vibration sensors.
a) Operational Temperature Range: -40 degrees F to 185 degrees F.
b) Temperature Reading Accuracy: +/- 5 degrees F.

b. Data Monitors (DMs): DMs shall be housed within the LCS enclosure near the pump.
1) DMs shall have 22 available data inputs:
a) 12 – Vibration inputs (as required).
b) 4 – Temperature inputs (as required).
c) 1 – Techometer input.
d) 3 – Analog (4 to 20 mA).process inputs(Speed Feedback from VFD and 2 Spare from VFD).
e) 2 – Digital process inputs (Running, Spare).
2) Each DM shall be able to collect data from every sensor every5 seconds.
3) Based on user defined dead bands the DM shall be able to decide the relevant data and alarm information to be sent up to the communication module. Deadbanding indicates ability to limit the transmitted data based on condition, magnitude change, and/or time.
4) Each data input shall have a user defined alarm delay. This feature avoids false alarms for minor transient conditions.
5) Each DM will be capable of calculating and transmitting vibration spectra (FFTs) to the GUI for user analysis.
6) Each DM will have the intelligence to automatically collect FFTs based on schedule or alarm.
7) In addition to monitoring and alarming overall sensor values, each DM shall perform vibration FFT Band Alarm calculations. Band alarms are user defined frequency range where alarms can be set. The monitoring system shall have a minimum of 10 user defined band alarms per vibration axis.
8) A relay output shall be available for local alarm annunciation to be wired back to VFD.
9) Each DM shall be contained in NEMA 4X, IP66 rated enclosure with a reset button and LEDs for local alarm notification.
10) Each DM shall be powered by 12-24 VDC by a power supply or by loop power from the motor starter enclosures.
11) Each DM shall be FCC compliant.

c. Communication Module Wirelessly/Internet Gateway: The communication module shall collect local data and send up the data to the GUI by the way of a hardwired Ethernet connection. The CMs provide the following features:

1) Act as a single point of contact with the internet.
2) NEMA 4X enclosure.
3) FCC compliant with 120VAC.
4) Powered by 12 VDC from power supply or loop power.
5) Perform software updates to CM and DM remotely without local intervention.
6) Ethernet connection for communicating with manufacturer's Internet monitoring server.

d. Graphical User Interface (GUI): The GUI provides graphical illustration of collected data. The GUI shall have the following feature as a minimum:
1) Dashboards: Customizable GUI.
2) Graphing multiple sensors and sensor types on the same plot.
3) Trending archived data (data shall be archived for a minimum of 1year).
4) Customizable on demand reporting capabilities.
5) Alarm and warning notifications sent by email or phone.
6) System shall be automatically capture alarm logs.
7) Notes shall be available for capturing maintenance logs along with alarm logs.
8) Display of live and archived FFTs and TWF.
9) Perform all commissioning and setup of the system remotely. Nolocal access shall be required once the system is communicating and powered.

e. Installation:
1) Mechanical and electrical installation of sensors and communicating system shall be by the contractor; however, thesystem configuration, software, and provisioning shall be performed by the manufacturer, on site.
2) Once mounted and powered, the maintenance and troubleshooting of the system shall be performed remotely and shall not require local intervention.
3) The system shall not require local software to be installed, supported, or maintained.

2.5 ANCHORAGE DEVICES

A. Provide anchorages and fasteners of Type 316 stainless steel of ample size and strength for purpose intended, sized by equipment manufacturer. Anchorage devices shall conform to Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

2.6 SHOP PAINTING

A. Clean and prime coat ferrous metal surfaces of products in shop per Section 09910, Painting.

B. Coat machined, polished, and non-ferrous metal surfaces and similar unpainted surfaces with corrosion prevention compound that shall be maintained during storage and through start of equipment operation.

2.7 LUBRICANTS

A. Provide lubricants, oil, and grease as required for initial operation. Products shall be as recommended by manufacturers of pump and motor.

2.8 SOURCE QUALITY CONTROL

A. Pump Shop Tests: Shop test each pump as follows:
   1. Hydrostatically test pump column and discharge head to twice discharge head or 1.5 times pump shutoff head, whichever is greater, per ANSI/HI 2.6.
   2. Performance Test:
      a. Pump bowls, strainer, job pump head, and job motor (or shop motor that is an electrically identical) shall be performance tested in pump manufacturer's factory. Pump manufacturer shall provide pump column, lineshaft, and other equipment and material required for performance test.
      b. Per Section 01210, Allowances, the CONTRACTOR shall pay all costs for one representative of OWNER and one representative of ENGINEER to witness performance tests at pump manufacturer's factory.
         1) Perform at least one performance (witness) test on each pump. Allow OWNER and ENGINEER to witness each performance tests and retests at OWNER's option.
         2) Dates of performance tests shall be acceptable to OWNER and be agreed upon in writing at least ten days prior to actual test. All witness tests at pump manufacturer's factory shall be performed on same day or on consecutive days to minimize the time required of OWNER and ENGINEER for witness tests.
         3) OWNER and ENGINEER will be responsible for cost of their time for first test on each pump, and for time to travel to and from pump manufacturer's factory once. Cost of lodging, meals, and travel expenses shall be responsibility of CONTRACTOR's pump manufacturer.
         4) If re-testing is required, all time and expense costs incurred by OWNER and ENGINEER will be deducted from money due CONTRACTOR. If tests are not performed on agreed-upon date as a result of CONTRACTOR's or pump manufacturer's action and OWNER or ENGINEER incurs lost time as a result of this action, associated costs will be deducted from money due CONTRACTOR.
      c. At least four weeks prior to scheduled pump performance test, pump manufacturer shall furnish ENGINEER with proposed test procedure. Proposed test procedure shall set forth:
         1) Pump speeds at which performance test will be run.

2) Sample calculations illustrating how the head/capacity performance curves at full speed will be calculated from test readings.
3) Conversion factors or tables that relate test instrument readings to quantities being measured.
4) Description of proposed testing facility, including diagrams of equipment and proposed test set-up and list of instruments to be used in test. All instruments shall be calibrated within one year prior to test. Provide certification of instrumentation calibration if requested by ENGINEER.
5) Limitations of test stand and proposed deviations from ANSI/HI 2.6.

d. Assemble at pump manufacturer's factory the pump with number of bowls required, vortex breaker, at least one length of column and shaft, pump discharge head, and driver for performance tests. Performance test shall be in accordance with ANSI/HI 2.6 and ANSI/HI 9.6.5.

e. For shop performance tests, operate pump for at least thirty minutes at rated condition before recording data.

f. Operate pump assembly from zero to maximum capacity as shown on pump curve included in approved Shop Drawing. Results of performance test shall be shown on a plot of test curves showing head, flow, brake horsepower, bowl efficiency, current, and net positive suction head required. Readings shall be taken at a minimum of five evenly-spaced capacity points including shut-off, design points, and minimum head at which pump is designed to operate. Curves shall be corrected for column and discharge head losses, shaft friction loss, and operating speed to show the anticipated field performance of the complete pump assembly.

g. Conduct performance tests within plus-or-minus five percent of design maximum speed and capacity. No minus tolerance is allowed with respect to capacity, total head, and specified efficiency at design point. For variable speed pumps, run performance test at full load speed, and derive a family of curves from test data. Family of curves shall be for speeds from 40 to 100 percent of full load speed.

h. Each test shall be witnessed by a registered, licensed professional engineer who may be an employee of pump manufacturer. Registered professional engineer shall sign and seal all copies of test curves and certify that hydrostatic tests were performed. Professional engineer's certification shall show the state of the professional engineer's registration and registration number. Professional engineer's name on seal shall be legible.

i. Provide to ENGINEER certified raw and reduced test data and curves covering each performance test within 14 days after completing performance test. Provide number of copies of test results specified for Shop Drawings. Include with submittal of performance test report the results of hydrostatic tests and copy of approved test procedure.

B. Job Motor Shop Tests: Refer to requirements of Division 16, Electrical.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine conditions under which products are to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install products in conformance with governing codes, applicable standards, manufacturer's instructions and recommendations, and the Contract Documents.

B. Anchorages and Base plates or Soleplates:
   1. Install pumps on concrete bases. Provide anchorages in new or existing concrete, as applicable, per equipment manufacturer's recommendations and the Contract Documents. Equipment manufacturer shall supply templates to facilitate location of anchorages for equipment. CONTRACTOR shall coordinate with Supplier and equipment manufacturer to assure timely receipt of required templates.
   2. Pour concrete bases up to one inch below equipment baseplate or soleplate as applicable. Base with equipment mounted thereon or soleplate shall then be accurately shimmed to grade and spaces between filled with non-shrink grout per Section 03600. After grout has reached its initial set, exposed edges shall be neatly cut back 1/2-inch and the edges neatly finished with 1 to 2 cement mortar.

C. General:
   1. Conform to ANSI/HI 2.4.
   2. Perform all drilling and fitting required for installation. Set the products accurately in location, alignment, and elevation, plumb and true.
   3. Fit exposed connections accurately together to form tight hairline joints.
   4. Provide 1-inch diameter hard copper pipe from each pump to convey water to drainage inlet.
   5. Provide utility connections per the Contract Documents. Verify that utilities and valves are tested and operational before placing equipment into operation. Connection of discharge nozzle to piping shall conform to ANSI/HI 9.6.2.
   6. Align and adjust equipment including shafting, motors, drives, and piping in presence of ENGINEER
   7. Install for initial operation lubricants recommended by equipment manufacturer
   8. Prior to energizing motor driven equipment, rotate drive motor by an external source to demonstrate free operation of mechanical parts. Do not energize equipment until safety devices are installed, connected, and functional.

D. Field painting shall conform to Section 09900, Painting.

E. Conform to Section 01751, Starting and Placing Equipment in Operation.

3.3 FIELD QUALITY CONTROL

A. Site Tests:
   1. Following installation, CONTRACTOR and a qualified field service representative of equipment manufacturer shall conduct operating tests of all equipment, functions, and controls at the Site in presence of ENGINEER. Should tests result in malfunction, make necessary repairs, revisions, and adjustments and restart test from the beginning. Repeat tests and repairs, revisions, and adjustments until, in opinion of ENGINEER, installation is complete and equipment is functioning properly and accurately, and is ready for permanent operation.
   2. Conform to Section 01752, Equipment and Systems Startup and Performance Testing.
   3. Field Vibration Tests:
      a. Provide services of an expert in the field of vibration analysis and control with qualifications acceptable to ENGINEER for conducting vibration tests following installation of pumps and prior to start-up.
      b. Vibration testing and criteria for acceptance shall be per ANSI/HI 9.6.4.
      c. Perform a bump test on pump in each of two orthogonal planes, one of which shall include pump's discharge nozzle, to ensure that pumps will not develop lateral or torsional critical speeds. Perform tests after pump is installed, under both operating and non-operating conditions. Other suitable tests may be substituted subject to ENGINEER's approval of CONTRACTOR's written request and description of tests proposed.
      d. Obtain vibration measurements at pump's upper motor bearing while operating over its speed range. Obtain measurements in each of two orthogonal horizontal directions, one of which shall be in plane of greatest vibration and in vertical (pump axial) direction.
      e. Submit to ENGINEER report of successful vibration tests.
   4. Field Operating Test:
      a. Field test equipment and its controls in local mode, followed by demonstrating proper operation and controls in automatic mode. Demonstrate that each part and component of system individually and all parts and components together function properly in manner intended. Total duration of testing shall be two hours, continuous and uninterrupted, in automatic mode. All testing equipment and manpower shall be by CONTRACTOR.
      b. Conform to applicable provisions of ANSI/HI 9.6.5.

B. Manufacturer's Services: Provide a qualified, factory trained serviceman to perform the following:
   1. Supervise unloading and installation of equipment.
   2. Instruct CONTRACTOR in installing equipment.
   3. Inspect and adjust equipment after installation and ensure proper operation.

4. Test-operate the products in presence of ENGINEER and verify that equipment conforms to Contract Documents.
5. Instruct OWNER's personnel in operating and maintaining the products.
6. Manufacturer's representative shall make a minimum of four visits, with a minimum of eight hours onsite for each visit. First visit shall be for unloading supervision and instruction of CONTRACTOR in installing equipment; second visit shall be for assistance in installing equipment; third visit shall be for checking completed installation and start-up of system; fourth visit shall be to instruct operations and maintenance personnel. Representative shall revisit the Site as often as necessary until installation is acceptable.
7. Training: Furnish services of qualified factory trained specialists from manufacturer to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of the products. Training requirements, duration of instruction, and other qualifications shall be per Section 01821, Instruction of Operations and Maintenance Personnel.
8. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to Site shall be included in the Contract Price.

+ + END OF SECTION + +

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SECTION 11115

INLINE – VERTICAL CENTRIFUGAL PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install inline vertical centrifugal pumps complete and operational with motors, control equipment and accessories as shown and specified.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before the inline vertical centrifugal pumps Work.

C. Related Sections:
   1. Section 03600, Precision Grouting.
   2. Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.
   3. Section 13420, Primary Sensors and Field Instruments.
   4. Section 13430, Control Panels and Enclosures.
   5. Section 16220, Motors.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Gear Manufacturers' Association, (AGMA).
   2. American National Standards Institute, (ANSI).
   3. American Society for Testing Materials, (ASTM).
   4. Standards of American Water Works Association, (AWWA).
   5. Institute of Electrical and Electronic Engineers, (IEEE).
   6. Standards of the Hydraulic Institute, (HI).
   7. National Electrical Code, (NEC).
   8. Standards of the National Electrical Manufacturers Association, (NEMA).
   9. National Sanitation Foundation, (NSF).

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from an inline vertical centrifugal pumps manufacturer.
   2. The inline vertical centrifugal pumps equipment manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall assembly by the centrifugal end suction pumps-dry pit equipment manufacturer.

1.4 SUBMITTALS

A. Action Submittals:
   Submit the following:
   1. Product Data:
      a. Manufacturer's literature, illustrations, specifications and engineering data including: dimensions, materials, size, weight, performance data and curves showing overall pump efficiencies, required net positive suction head, allowable suction lift, flow rate, head, brake horsepower, motor horsepower, speed and shut-off head.
      b. Motor tests and data as described in Part 2.
   2. Shop Drawings:
      a. Fabrication, assembly, installation and wiring diagrams.

B. Informational Submittals:
   Submit the following:
   1. Source Quality Control:
      a. Guarantee with proof of ability to maintain efficiency.
      b. Certified pump tests.

C. Closeout Submittals:
   Submit the following:
   1. Operation and Maintenance Data:
      a. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.
      b. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operations and Maintenance Data.

1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
   1. Deliver materials to the Site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to prevent delay of the Work.

B. Storage and Protection:
   1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
   2. Comply with Section 01661, Storage and Protection of Products.

C. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the Site. CONTRACTOR shall notify ENGINEER, in writing, if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 EQUIPMENT PERFORMANCE

A. Description:
   1. Pumps shall be inline vertical centrifugal pumps.

B. Performance Criteria:
   1. Pumps shall comply with the minimum design conditions specified below and shall be specially designed, constructed, and installed for the service intended:

Design Conditions	**Pump No. 1**
Location:	PT/GAC Building
Use:	GAC Backwash Supply
Number required:	1
Design Flow, (gpm):	1,000
Design TH, (ft.):	73
Shutoff Head (ft)	93

Efficiency at Design, (percent):	80% minimum
Motor, (Hp):	25
Maximum Speed, (rpm):	1,750
Suction Size, (in.):	8
Available NPSH at Design, (ft.):	25
Flow at 2nd Design Point, (gpm):	1,200
TH at 2nd Design Point, (ft.):	64
Liquid Pumped:	Finished Water
Temperature, (ºF):	34-90

2.2 MANUFACTURERS

A. Products and Manufacturers: Provide one of the following:
   1. Aurora Pump, Model 382A.
   2. Or equal.

2.3 DETAILS OF CONSTRUCTION

A. Pump Materials and Construction:
   1. Casing: Cast-iron with handhole and cover.
   2. Impeller Type: Enclosed, dynamically balanced.
   3. Impeller Material: Bronze.
   4. Casing Wear Ring: Bronze.
   5. Shaft Sleeve: Bronze.
   7. Shaft: Carbon steel.
   6. Seals: 303 stainless mechanical seal with Buna-N, Ni-Resist and stainless steel metal parts.
   7. Bearings: Anti-friction, grease lubricated with a minimum B-10 life of 100,000 hours.
   8. Baseplate: Structural steel or cast-iron provided with means for collecting and draining oil and water.
   9. Furnish with 125 pound ANSI connection flanges and handhole.
   10. Anchor bolts and inserts shall be furnished under this Section and shall be sized and installed in accordance with the manufacturer's recommendations.
   11. All bolts, nuts and cap screws shall have hexagon heads.
   12. Brass or stainless steel nameplates giving the manufacturer's model and serial number, rated capacity, head, speed and all other pertinent data shall be attached to the pump.

B. Motors:

1. Motors shall conform to the requirements of Section 16220, Motors.
2. Totally enclosed, fan-cooled, carbon steel, solid shaft, ball bearing type, close coupled.
3. Motors shall be in accordance with all current applicable standards of NEMA, IEEE, AFBMA, NEC, and ANSI.
4. Motors shall be normal starting torque, normal slip, squirrel cage induction type.
5. Motors shall be capable of carrying full load current continuously without injurious temperature rise in an ambient temperature of 40°C.
6. Motors shall be provided with a service factor of 1.15.
7. Motors shall be of sufficient size so that there will be no overload on the motor above rated nameplate horsepower under any condition of operation from shut-off to zero head, unless otherwise specifically permitted in this Section.
8. Motor thrust bearings shall be adequate to carry continuous thrust loads under all conditions of pump operation from zero head to shut-off.
9. Locked rotor currents shall be as specified in NEMA standards.
10. Lubrication may be grease or oil type.
11. Motor Tests and Data:
    a. For each motor from one to ten horsepower in size, furnish an inspection report for the motor or for a previously manufactured electrically duplicate motor which was tested. Provide the following minimum data:
        1) Running light current.
        2) Locked rotor current.
        3) Winding resistance measurement.
        4) High potential test.
        5) Bearing inspection.
    b. For each motor larger than ten horsepower, furnish a certified motor data sheet for the actual motor or for a previously manufactured electrically duplicate motor which was tested. Provide the following minimum data:
        1) Starting torque.
        2) Efficiency at 1/2, 3/4 and full load.
        3) Power factor at 1/2, 3/4 and full load.
        4) Percent slip.
        5) Running light, full load and locked rotor current.
        6) Current balance check.
        7) Vibration check.
        8) Temperature rises and results of dielectric tests.
        9) Motor type and frame size.
        10) Bearing type and lubrication medium.
        11) Insulation and enclosure type.

2.6 TOOLS AND SPARE PARTS

A. Each pump shall be furnished with the following:
    1. One mechanical seal or packing for each gland.
    2. One set of gaskets.

3. One shaft sleeve.
4. Two sets of special tools required for normal maintenance or operation.

B. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the OWNER at the conclusion of the project.

2.7 PAINTING

A. Pumps, motors, drives, frames, baseplates, appurtenances, etc., shall receive manufacturer's standard finish paint system prior to shipment.

B. Machined, polished, and non-ferrous surfaces shall be coated with corrosion prevention compound.

C. Field painting shall conform to the requirements of Section 09910, Painting.

2.8 SOURCE QUALITY CONTROL

A. Shop Tests:
1. Pump casings shall be hydrostatically tested to twice the discharge head or 1-1/2 times the shutoff head, whichever is greater.
2. Running Test: Pump assembly shall be operated from zero to maximum capacity as shown on the approved curve. Results of the test shall be shown in a plot of test curves showing head, flow, horsepower, efficiency, and current. Readings shall be taken at a minimum of five evenly spaced capacity points including shut-off, design point and minimum head for which pump is designed to operate.
3. Each test shall be witnessed by a Registered Professional Engineer, who may be an employee of the manufacturer. The Registered Professional Engineer shall sign and seal all copies of curves and shall certify that hydrostatic tests were performed. Tests shall be conducted in conformance with applicable methods per Hydraulic Institute.
4. Pumps shall not be shipped until the ENGINEER has approved the test reports.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR shall verify that structures, pipes and equipment are compatible.

B. Make adjustments required to place system in proper operating condition.

3.2 INSTALLATION

A. Manufacturer’s representative shall check and approve the installation prior to operation. Manufacturer’s representative shall field test and calibrate the equipment to assure that the system operates to the OWNER’S satisfaction.

B. All pumping units shall be installed on concrete bases and secured with anchor bolts in accordance with the manufacturer's recommendations and as shown. The concrete bases shall be poured up to 1-inch below the metal bases or soleplates. Concrete work and grout shall be in accordance with Division 03, Concrete. The base with the equipment mounted thereon, or the soleplate, shall then be accurately shimmed to grade and the spaces between filled with an approved non-shrink grout. After the grout has reached its initial set, exposed edges shall be cut back 1/2-inch and the edges neatly finished with 1 to 2 cement mortar. Where channel baseplates are used, the void inside the channel shall be filled with non-shrink grout and the open ends plastered with 1 to 2 cement mortar.

C. Neatly placed 1-inch hard copper pipe shall be provided for each non-submersible pump to convey leakage to nearest drainage inlet.

D. Installation shall include furnishing and applying an initial supply of grease and oil, recommended by the manufacturer.

E. Support piping independent of pump.

F. Check and align all pump, motor and flexible shafting.

3.3 START-UP AND TEST

A. CONTRACTOR shall verify that structures, pipes and equipment are compatible.

B. Make adjustments required to place system in proper operating condition.

3.4 FIELD QUALITY CONTROL

A. All equipment will be given running tests by CONTRACTOR at the job Site following installation of the equipment and controls. Should the tests indicate any malfunction, including but not limited to high vibration, CONTRACTOR shall make any necessary repairs and adjustments. Such tests and adjustments shall be repeated until, in the opinion of the ENGINEER, the installation is complete and the equipment is functioning properly and accurately, and is ready for permanent operation.

B. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of two visits, minimum five hours on-Site for each visit, to the Site. The first visit shall be for assistance in the installation of equipment. Subsequent visits shall be for checking the completed installation, start-up and training of the system. Manufacturer's representative shall test operate the system

in the presence of the ENGINEER and verify that the equipment conforms to the requirements. Representative shall revisit the Site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

C. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 11117

SUBMERSIBLE END SUCTION PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals required to furnish and install clean water submersible, end suction centrifugal pumps complete and operational with motors, control equipment, and accessories as shown and specified. Anchorage devices are included in the scope of this Section.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before submersible end suction pump Work.

C. Related Sections:
   1. Section 05051, Anchor Bolts, Toggle Bolts, and Concrete Inserts.
   2. Section 05542, Floor Access Hatch Covers.
   3. Section 09910, Painting.
   4. Section 15061, Ductile Iron Pipe.
   5. Division 16, Electrical Contract Drawings.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ANSI/HI 1.3, Standard for Centrifugal Pumps for Design and Application.
   2. ANSI/HI 1.4, Standard for Centrifugal Pumps for Installation, Operation, and Maintenance.
   3. ANSI/HI 1.6, Centrifugal Pump Tests.
   4. ANSI/HI 9.1-9.5, Standard for Pumps – General Guidelines for Types, Definitions, Application, Sound Measurement, and Decontamination.
   5. ANSI/HI 9.6.2, Standard for Centrifugal and Vertical Pumps for Allowable Nozzle Loads.
   6. ANSI/HI 9.6.3, Standard for Centrifugal and Vertical Pumps for Allowable Operating Region.
   7. ANSI/HI 9.6.5, Centrifugal and Vertical Pumps for Condition Monitoring
   8. ANSI/HI 9.8, Pump Intake Design.
   9. ANSI/HI 11.6, Submersible Pump Tests.
   10. IEEE 85, Airborne Sound Measurements- Rotating Electrical Machinery.

11. NEMA MG-1, Motors and Generators.

1.3 QUALITY ASSURANCE

A. Supplier's Qualifications:
   1. Supplier shall have a minimum of five years experience producing substantially similar equipment to that required for the Project and shall be able to provide documentation of at least five installations in satisfactory operation for at least five years each.

B. Component Supply and Compatibility:
   1. Obtain all products included in this Section, regardless of component Supplier, from one submersible end suction pump manufacturer.
   2. Submersible end suction pump Supplier shall review and approve or prepare all Shop Drawings and submittals for all components provided under this Section.
   3. All components shall be suitable for specified service conditions and shall be integrated into overall assembly by the submersible end suction pump Supplier.

C. Certifications
   1. Certification of Compliance:
      a. Obtain certification of compliance with the Contract Documents from the submersible end suction pump manufacturer on manufacturer letterhead; certification by manufacturer's representatives is not acceptable.
      b. Certification shall be worded as follows:

"[*Insert manufacturer's name*] proposes to supply equipment included in Section 11117 for the Northern Kentucky Water District, Erlanger, Kentucky, Taylor Mill Water Treatment Plant Advanced Treatment Improvements project. We have examined the Contract Documents and understand of the Project requirements insofar as they affect the proposed products. We certify that the products will operate satisfactorily under the conditions described in the Contract Documents and that the products meet the requirements of the Contract Documents:

[List exceptions, deviations or changes necessary or recommended to accommodate the proposed products.]

We further certify that the products to be furnished shall conform to the standards listed in Section 11117, End Suction Pumps – Submersible, of the Contract Documents.

[List exceptions, deviations or changes necessary to accommodate the proposed products.]

_____ _____

Authorized Signature & Title Date"

c. Provide justification for exceptions, variations, deviations, or changes. ENGINEER will determine whether exceptions, deviations, and changes are acceptable. Exceptions, variations, deviations, and changes may result in rejection of products.
d. Provide certification before submitting Shop Drawings. Shop Drawings will not be reviewed prior to receipt of certification.
e. Acceptance of certification shall not relieve CONTRACTOR of responsibility for adequacy of all products.
f. Submittal of certification shall not relieve CONTRACTOR and Supplier of requirement to comply with submittal procedures in the Contract Documents.

1.4 SUBMITTALS

A. Action Submittals:
Submit the following:
1. Shop Drawings:
a. Shop Drawings of pump controls specified in this Section.
2. Product Data:
a. Manufacturer's literature, illustrations, specifications, paint certification (if required) and engineering data including; dimensions, materials, size, weight, and part lists for all components in sufficient detail to allow an item-by-item comparison with the Contract Documents.
b. Pump performance data and curves showing overall pump efficiencies, required net positive suction head (NPSH), allowable suction lift, flow rate, head, brake horsepower, motor horsepower, speed, and shut-off head. Curves shall range from minimum flow to shut-off head at for full speed and all speed curves specified. Curves shall indicate Preferred Operating Region (POR) and Allowable Operating Region (AOR), as defined in ANSI/HI 9.6.3. Specify recommended ratio of available NPSH divided by required NPSH for water service.
c. Motor Data: Furnish certified motor data sheet for previously tested, electrically duplicate motor to that specified, including the following:
1) Speed-torque relationship.
2) Slip at full load.
3) Running light, full load and locked rotor current.
4) Temperature rises and results of dielectric tests.
5) Bearing type and lubrication medium
6) Insulation class and temperature ratings.
3. Testing Plans, Procedures, and Testing Limitations:
a. Provide pump Supplier's proposed shop testing plan, including complete list of testing facility limitations.
b. Provide proposed field testing plan.

B. Informational Submittals:
   1. Certificates: Provide certificate of compliance as specified in this Section.
   2. Manufacturer Instructions:
      a. Provide Supplier's instructions for handling and installing products.
      b. Setting drawings, templates, and directions for installing anchor bolts and other anchorages.
   3. Field Quality Control Submittals:
      a. Results of field testing.
      b. Submit a written report of the results of each visit to Site by pump manufacturer's service representative, including purpose and time of visit, tasks performed, and results obtained.
   4. Qualifications Statements:
      a. Provide Supplier's qualifications as specified in Quality Assurance article of this specification.

C. Closeout Submittals:
   Submit the following:
   1. Operation and Maintenance Manuals:
      a. Submit complete operation and maintenance manuals, including field test reports, maintenance data and schedules, description of operation, and spare parts information.
      b. Provide operation and maintenance manuals per Section 01781, Operations and Maintenance Data.
   2. Warranty Documentation:
      a. Manufacturer's Standard Warranty.
      b. Special Warranty, if specified.

D. Maintenance Material Submittals:
   Furnish the following:
   1. Tools:
      a. Furnish two sets of special tools required for normal operation and maintenance of products furnished.

1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
   1. Prior to shipping, completely inspect products to assure that components are complete and comply with all requirements. Box or crate products as required to prevent damage during shipment. Protect machined surfaces and matching connections to prevent damage.
   2. Deliver products to Site to ensure uninterrupted progress of the Work. Deliver anchorage products that are to be embedded in concrete in ample time to prevent delaying the Work.
   3. Inspect all boxes, crates, and packages upon delivery to Site and notify ENGINEER in writing of loss or damage to products. Promptly remedy loss

and damage to new condition per manufacturer's instructions.

B. Storage and Protection:
   1. Keep all products off ground using pallets, platforms, or other supports. Protect steel, packaged materials, and electronics from corrosion and deterioration.
   2. Comply with Section 01661, Storage and Protection of Products.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than one year from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 EQUIPMENT PERFORMANCE

A. System Description:
   1. Pumps shall be submersible end suction centrifugal type. Pumps shall be constructed for operation under complete submersion, partial submersion, and dry conditions. Each pump shall be suitable for its intended service.
   2. Pumps shall comply with ANSI/HI 1.3, ANSI/HI 9.6.3, and ANSI/HI 9.8.

B. Design and Performance Criteria: Each pump shall comply with the following:

Design Conditions	**Pump Type A**	**Pump Type B**	**Pump Type C**	**Pump Type D**
Location:	GAC Equalization Basin			
Use:	GAC Equalization Basin Recycle			
Fluid Pumped:	Equalization Water			
Number Required:	2			
* Design Flow at First Design Point (gpm)	300			
* Design Total Head at	33			

Design Conditions	Pump Type A	Pump Type B	Pump Type C	Pump Type D
First Design Point (ft)				
Minimum Pump Efficiency at First Design Point (percent)	50			
** Available NPSH at First Design Point (ft)	25			
Min. Sphere Diameter (in):	2			
Discharge Nozzle Dia. (in.):	4			
*** Flow at Second Design Point (gpm)	530			
Total Head at Second Design Point (ft)	22.5			
Shutoff Head (ft)	48.5			
**** Motor Size (hp) and Maximum Speed (rpm):	5 / 1745			
Motor Voltage/Phase/Hertz	460/3/60			
Solids (percent):	<5%			
Fluid Temperature (deg. F):	34-90			

Notes:

* At maximum speed.

** Required NPSH shall be for size impeller furnished. If impeller is trimmed, provide curve for impeller as trimmed.

*** Flow at Second Design Point total head shall be within ten percent of flow value specified.

**** At all points on pump curve, pump horsepower requirements shall not exceed specified motor horsepower.

2.2 MANUFACTURERS

A. Products and Manufacturers: Provide products of one of the following:
   1. Flygt Corporation, Model NP3102-463.
   2. Or equal.

2.3 DETAILS OF CONSTRUCTION

A. Pump Materials and Construction (Standard Duty):
   1. General:
      a. Construct pumps for fluid service specified.
      b. Construct pumps and appurtenances, including cable, for continuous submerged operation without leakage in specified depth of water.

c. Pump body shall include lifting eye or stainless steel bail suitable for bearing weight of pump unit during removal and installation.

2. Stator casings, oil casing, sliding bracket, volute and impeller shall be close grained grey cast iron.
3. Impeller shall be enclosed single or multi vane non-clog, dynamically balanced. Wear ring shall be stainless steel.
4. External Hardware: All bolts, nuts, and cap screws shall have hexagon heads and be of stainless steel.
5. Shaft: Stainless steel, close coupled.
6. Seals: Double mechanical seal running in an oil reservoir, composed of two face seals, one stationary and one rotating tungsten-carbide ring held in contact by spring pressure. The seal shall require neither maintenance nor adjustment and shall be easily replaceable. Cartridge seals shall not be accepted.
7. Coating: All surfaces in contact with water shall be protected with an epoxy or rubber asphalt coating resistant to water.
8. Bearings: Anti-friction, permanently grease lubricated having a B-10 bearing life of not less than 50,000 hours.
9. Stainless steel nameplates giving the manufacturer's model and serial number, rated capacity, head, speed, and all other pertinent data shall be attached to the pump.
10. The pumping units shall automatically and positively mate with its discharge piping permanently when lowered into place. The pumps shall be removable for inspection or service requiring no bolts, nuts, or other fastenings to be disconnected. Lifting safety type hooks shall be provided at both ends of the cable. The manufacturer shall provide guide rail brackets, ductile iron base elbow, self-seating flange and disconnect and other items required for a guide rail type removal system.
11. All components of the guide rail system shall be Type 316 stainless steel.
12. Each pump shall be provided with adequate stainless steel lifting chain to facilitate pump removal. The nylon line shall be sized to sustain all tensile stresses during lifting of the pump. The stainless steel cable shall be connected to the lifting eye. A steel forged "grip-eye" shall be provided separately to connect to the end of the lifting chain of the pump.

B. Motors for Standard Duty Pumps:
1. Housing: Cast iron.
2. Cable Connection: Provide with strain relief.
3. Voltage, phase, and frequency shall be as specified under "Design and Performance Criteria" in this Section.
4. Motor shall be non-overloading for entire pump operating curve, shall have 1.15 service factor, and shall provide full rated horsepower with a voltage unbalance of three percent.
5. Motors shall be in accordance with all current applicable standards of NEMA, IEEE and ANSI. Motors for use with variable frequency drives shall have

insulation system constructed in compliance with or exceeding NEMA MG-1 Part 31.

6. Motors shall be capable of carrying full load current continuously without injurious temperature rise under all conditions of submersible operation.
7. Motor thrust bearings shall be adequate to carry continuous thrust loads under all conditions of pump operation from zero head to shut-off.
8. Motor Protective Control Sensors:
    a. Three thermistors or thermal switches in the stator winding coils (one per phase) to monitor motor temperature. Temperature switches tripped at 140 degrees C.
    b. Moisture sensors to monitor leakage in the stator housing and seal chamber.
9. Provide one fault contact (rated at least 2A at 120VAC) for indication of each fault condition and for shutdown. Pump manufacturer shall ship loose pump manufacturer's 120VAC motor protective relay/device to MCC manufacturer, under Specification 16440, for installation within MCC bucket.

C. Accessories: Provide the following for each pump unless otherwise specified.
1. Anchor bolts and anchorage devices Type 316 stainless steel in accordance with Section 05051, Anchor Bolts, Toggle Bolts, and Concrete Inserts.
2. Discharge Elbow: Conforming to Section 15061, Ductile Iron Pipe.
3. Pump Removal System:
    a. Pumps shall automatically and positively mate with associated discharge piping when pump is lowered into place. Pumps shall be removable for inspection or service without requiring removal of bolts, nuts, or other fastenings.
    b. Provide for each pump guide rails of extra-heavy Type 316, Schedule 80 stainless steel.
    c. Pump manufacturer shall provide guide rail brackets, self sealing flange, stainless steel cable or chain (as applicable) holder with support grip, and other items necessary for complete guide-in, pump removal system.
4. Provide one portable pump hoist for each set of pumps furnished. Hoist shall have capacity sufficient to hoist one associated pump at a time.
    a. Manufacturer:
        1. Thern, Series 5110 Portable Davit Crane with Model 510R wheel base.
        2. Or Equal.
    b. Accessories:
        1. Provide electric winch.
        2. Provide 316 stainless steel wire rope with stainless steel eye hook and swaged ball fitting, minimum 28 ft.
5. Access Frames and Covers: Provide with each pump an aluminum alloy access frame and cover complete with heavy-duty stainless steel hinges and locking hasp. Cover shall be capable of 150 psf live loading and have safety checked or abrasive, non-slip surface. Opening sizes shall be as shown on the Drawings.

Access frames and covers shall conform to Section 05542, Floor Access Hatch Covers.

D. Controls:
   1. Provide the control logic as shown on the Instrumentation and Electrical Drawings.
   2. The level switches shall be furnished under Division 13, Special Construction.

2.4 FINISHING

A. Shop Finishing:
   1. At the factory, pumps, motors, and appurtenances shall receive manufacturer's standard finish paint system suitable for service conditions specified in this Section.
   2. Coat machined, polished, and non-ferrous surfaces with corrosion prevention compound.

B. Field painting shall conform to Section 09910, Painting. Touch-up of factory-applied finishes shall be compatible with factory-applied finish and specified service conditions.

2.5 SOURCE QUALITY CONTROL

A. Motor Tests and Data:
   1. For each motor, provide an inspection report for job motor or a previously tested electrically duplicate motor. Provide the following minimum data:
      a. Running light current.
      b. Locked rotor current.
      c. Winding resistance measurement.
      d. High potential test.

2.6 EQUIPMENT PERFORMANCE

A. Each model of pump shall be furnished with a manufacturers repair kit that shall include as a minimum the following:
   1. One complete rebuild kit per pump including seal, bearings, and O-ring.

A. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the OWNER at the conclusion of the Project.

PART 3 – EXECUTION

3.1 INSPECTION

A. Examine conditions under which products are to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Install products in conformance with manufacturer's instructions and recommendations, and the Contract Documents.

B. Anchorages:
   1. Install pumps on concrete bases. Provide anchorages in new or existing concrete, as applicable, per equipment manufacturer's recommendations and the Contract Documents. Equipment manufacturer shall supply templates to facilitate location of anchorages for equipment. CONTRACTOR shall coordinate with Supplier to assure timely receipt of required templates.

C. General:
   1. Conform to ANSI/HI 1.4.
   2. Perform all fitting required for installation. Set products accurately in location, alignment, and elevation, plumb and true.
   3. Provide utility connections per the Contract Documents. Support piping and valves independent of pump. Verify that utilities and valves are tested and operational before placing equipment into operation. When pumps are connected to piping with rigid hardware, connection of discharge nozzle to piping shall conform to ANSI/HI 9.6.2.
   4. Align and adjust products and piping in presence of ENGINEER
   5. Provide for initial operation lubricants recommended by equipment manufacturer
   6. Prior to energizing motor driven equipment, rotate drive motor by an external source to demonstrate free operation of mechanical parts. Do not energize equipment until safety devices are installed, connected, and functional.

D. Field painting shall conform to Section 09910, Painting.

E. Conform to Section 01751, Starting and Placing Equipment in Operation.

3.3 FIELD QUALITY CONTROL

A. Site Tests:
   1. Following installation, CONTRACTOR and qualified field service representative of equipment manufacturer shall conduct operating tests of all equipment, functions, and controls at Site, in presence of ENGINEER. Should tests result in malfunction, make necessary repairs, revisions, and adjustments and restart test from beginning. Repeat tests and repairs, revisions, and

adjustments until, in opinion of ENGINEER, installation is complete and equipment is functioning properly and accurately, and is ready for permanent operation.

2. Conform to Section 01752, Equipment and System Performance Testing.
3. Field Operating Test:
   a. Field test equipment and its controls in local mode, followed by demonstrating proper operation and controls in automatic mode. Demonstrate that each part and component of system individually and all parts and components together function properly in manner intended. Total duration of testing shall be eight hours, continuous and uninterrupted, in automatic mode. All testing equipment and manpower shall be by CONTRACTOR.
   b. Conform to applicable provisions of ANSI/HI 9.6.5.

A. Manufacturer's Services:

Provide qualified, factory-trained serviceman to perform the following:

1. Instruct CONTRACTOR in installing equipment.
2. Inspect and adjust equipment after installation and ensure proper operation.
3. Test-operate the products in presence of ENGINEER and verify that equipment conforms to Contract Documents.
4. Instruct OWNER's personnel in operating and maintaining the products.
5. Manufacturer's representative shall make a minimum of three visits. First visit shall be for assistance in installing equipment; second visit shall be for checking completed installation and start-up of system; third visit shall be to instruct operations and maintenance personnel. Representative shall revisit the Site as often as necessary until installation is acceptable.
6. Training: Furnish services of qualified factory trained specialists from manufacturer to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of products. Training requirements, duration of instruction, and other qualifications shall be per Section 01821, Instruction of Operations and Maintenance Personnel.
7. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to Site shall be included in the Contract Price.

+ + END OF SECTION + +

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SECTION 11125

PROGRESSING CAVITY PUMPS

PART 1- GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and services for manufacturing, assembling, delivering, installing, testing, and placing into service all progressing cavity pumps including pumps, motors, bases, and appurtenances.
   2. Unless otherwise specified, the pump manufacturer shall furnish each pumping unit complete with drive motor and all other components and shall be held entirely responsible for the compatibility in all respects of all components furnished.

B. Coordination:
   1. Review installation procedures under other sections and coordinate the installation of items that must be installed with, or before, the Progressing Cavity Pumps.

C. Related Sections:
   1. Section 01330, Submittal Procedures.
   2. Section 03300, Cast-In-Place Concrete.
   3. Division 16, Electrical and Electrical Contract Drawings.
   4. Section 01781, Operations and Maintenance Data.
   5. Section 01781, Operations and Maintenance Data.

1.2 REFERENCE

A. Standards Referenced in this section are:
   1. ANSI B3.15 – Bearing Life
   2. ANSI B16.5 – Flat Face Flanges

1.3 QUALITY ASSURANCE

A. Qualifications
   1. Manufacturer must have been operating for a period of not less than 10 years prior to the bid date of this contract.

1.4 SUBMITTALS

A. Shop Drawings & Product Information:
   1. Descriptive Literature, catalog cuts, and dimensional prints clearly indicating all dimensions and materials of construction, shall be submitted on all items specified herein.
   2. At the time of submission, the contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in material or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than 1 year from date of Substantial Completion."

PART 2- PRODUCTS

2.1 SERVICE CONDITIONS

A. Performance Criteria
   1. Pumps shall comply with the following conditions:

Description	Residual Transfer Pumps
General Pump Requirements	
Suction Diameter	8 Inches
Discharge Diameter	8-Inches
Liquid to be Pumped	Thickened Residuals (0.5 – 5.0% Concentration)
Design Points	
Capacity	225 GPM
TDH	16 Feet
Motor Requirements	
Voltage	230/460
Phase	3
Hz	60
Horsepower	7.5
RPM	275
Enclosure	TEFC
Service Factor	1.15
Ratio	6.31:1

2.2 MANUFACTURERS

A. Manufacturer: Provide one of the following:
   1. Moyno 2000 design.
   2. Netzsch, Inc.
   3. Approved Equal.

2.3 DETAILS OF CONSTRUCTION

A. Mounting:
   1. The pump shall be cradle mounted to allow the vertical port to be rotated in 90 degree increments perpendicular to the centerline to facilitate pumping connections.
   2. Mount pump, gearbox, and motor on a common fabricated channel steel base plate a minimum of .25 inches thick.

B. Casing
   1. The stuffing box, drive adapter, and suction housings of the pump shall be thick-walled cast iron.
   2. All cast parts shall be free of sand holes, blow holes, and other defects.
   3. The suction housing shall incorporate two rectangular inspection ports, 180° apart, to permit access to the suction housing interior without disconnecting the piping.
   4. The suction and discharge connection shall be flat face flanges with bolt hole dimensions and spacing to ANSI standards. The suction and discharge flanges shall mate to ANSI standard, 8 inch, 125 lbs flat face flanges.

C. Rotors
   1. The rotor shall be of one-piece construction with integrally machined rotor head. Rotors made in long lengths and cut to size, with welded rotor heads, will not be accepted.
   2. The rotor shall be machined from alloy steel, ASTM A331, grade 4150. The rotor shall be of the single helix design with a hard chrome plate thickness of .010 inches for maximum abrasion resistance.

D. Stator
   1. The stators shall be of the double helix design and chemically bonded to the inside of a carbon steel tube. The Shore A durometer of the Nitrile stator shall be 71 + 4.
   2. The stator shall be machined with grooves to accept a 720°-retaining ring. The stator shall be fastened to the suction housing and discharge flange with removable clamp rings to facilitate stator removal. Stators held in place with inferior methods, such as tie rods that are prone to uneven tensioning and stator misalignment, will not be accepted.
   3. The replaceable stator gaskets shall be designed to prevent the material being pumped from contacting the stator bonding and tube. Stators

manufactured with seals integrally molded to the stator elastomer, that can be damaged during handling and installation and are not replaceable, will not be accepted.

4. Stators for the progressing cavity pumps shall be manufactured to size. Stators made in long lengths and cut to size will not be accepted.
5. Stator tensioning or adjusting devices, which distort rotor/stator compression and seal lines will not be accepted. The distorted compression reduces rotor life. The distorted seal lines reduce capacity and pressure capabilities of the pumping elements.

E. Gear Joints
1. The rotor shall be driven by means of a heavy duty, sealed gear joint drive train. The gear joints shall be of the grease lubricated crowned gear type, totally enclosed and protected by a wire reinforced elastomeric seal.
2. Mechanical components of the gear joint shall be designed to operate for 10,000 hours at the manufacturer's published maximum speeds and pressures. Pin joints are not acceptable whether bushed or unbushed.

F. Connecting Rod and Shaft
1. A rigid, splined connecting rod shall connect the gear joints of the drive shaft and eccentrically moving rotor. The drive shaft shall pass through the stuffing box and be attached to the adjacent gear drive.
2. The connecting rod shall be machined of alloy steel, ASTM 331-90, grade A8620. All diameters of the connecting rod are to be concentric within ± .003" TIR. Total angularity of the connecting rod shall not exceed 2.0°.

G. Drive Shaft
1. Shall consist of a drive shaft of one-piece construction through the shaft sealing area. The drive shaft shall be made of AISI 416 S.S.

H. Gear Motor
1. The integral gear motor is close-coupled to the adapter housing and pinned to the drive shaft. This design shall permit shorter overall length. The gearbox shall employ helical reduction gearing rated for AGMA Class II service minimum.
2. The bearings are integral to the gear motor, oil lubricated for a minimum B-10 life of 10,000 hours under maximum operating conditions. Heavy duty thrust bearings in the gearbox are required.

I. Stuffing Box
1. The stuffing box shall be equipped with a split-packing gland and split Teflon lantern ring to permit pump re-packing without removing the bearings or drive shaft components. Fittings will be provided for grease lubrication of the packing.

2.4 CONTROLS AND ACCESSORIES

A. Presence/Absence Detector: Provide a presence/absence detector with a contact wired to the motor starter to shutdown the pump on a run-dry run condition.
   1. General: The detector is an adjustable, RF impedance-sensing device, which is used to detect the presence or absence of process material within a pipe..
   2. Performance Requirement:
      a. Sensitivity: Senses capacitance as low as 0.15pF.
      b. Output: Snap action switch, SPDT rated not less than 10 amp resistive at 120VAC and 1/2 amp resistive at 125VDC.
      c. Adjustable Deadband Range: At least ± 20 percent from setting.
      d. Ambient Temperature Limits: -4 to 150 degrees F
      e. Housing: Heavy Duty, cast aluminum, NEMA 4X.
      f. Power Supply: 120 VAC ±10 percent, 50/60 Hz, 1.3 watts.
      g. Process Connection: Flange.
      h. Electrical Connection: 1-inch NPT.
   3. Manufacturer and Model:
      a. Princo, model L3515.
      b. Or equal.

2.5 SPARE PARTS

A. Stator – One (1)
B. Rotor – One (1)

PART 3- EXECUTION

3.1 INSTALLATION

A. General:
   1. Install in accordance with Manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

A. Site Tests & Manufacturer's Services:
   1. The Contractor shall include with his bid the services of the Equipment Manufacturer's field service technician.
   2. This service shall be for the purposes of check-out, initial start-up certification, and instruction of plant personnel.
   3. A written report covering the technician's findings and installation approval shall be submitted to the Engineer covering all inspections and outlining in detail any deficiencies noted.

++ END OF SECTION ++

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SECTION 11137

SUMP PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install sump pumps and appurtenances complete and operational as shown and specified.

B. The level switches for sump pump control, and interconnecting cable, shall be furnished by the pump manufacturer. The CONTRACTOR shall coordinate control panel locations, as required, with level switch installations to ensure that sufficient cable length is installed for a complete and operable installation.

C. General:
   1. The Drawings show a general arrangement of pumping equipment, connected piping and valves, with the approximate sizes and locations required unless specified herein or shown. The Plans are not intended to show exact dimensions for any specific pumping equipment. It is therefore anticipated that the dimensions of some equipment, in part or in whole, may have to be changed in order to accommodate the pumping equipment furnished.
   2. The pumps shall be totally submersible capable of continuous or intermittent operation while pumping drainage, in a totally, partially, or non-submerged condition without any excessive lateral or torsional vibration, heat build-up, or damage to motor or seals.
   3. Pumps shall be provided with automatic temperature cut-out, cut-in controls to protect the motor against overheating and clogging.
   4. The submersible pump and major components of the submersible pumping systems shall be the products of a single manufacturer.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer shall have experience in manufacturing sump pump equipment of the same or larger size to the pumping units specified. For a manufacturer to be determined acceptable for providing pumping equipment on this project, it must show evidence of five separate, substantially similar installations which have been in satisfactory operation for a minimum of 5 years.

B. All equipment provided under this Section shall be obtained from a single supplier or manufacturer who, with the CONTRACTOR, shall assume full responsibility for the completeness of the system. The supplier or manufacturer shall be the source of information on all equipment furnished regardless of the manufacturing source of that equipment.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. Local Plumbing Code, Latest Edition.
   2. Standards of the Hydraulic Institute.
   3. National Electric Code.
   4. Standards of National Electrical Manufacturers Association.
   5. Institute of Electrical and Electronic Engineers.
   6. American National Standards Institute.
   7. Standards of the American Water Works Association.

D. Shop Tests:
   1. Control Panel Tests: A complete operational test of the pump control panel shall be performed at the factory prior to shipment.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's literature, illustrations, specifications and engineering data including: dimensions, materials, size, weight, performance data and curves showing overall pump efficiencies, flow rate, head, brake horsepower, motor horsepower, speed and shut-off head.
   2. Shop Drawings Showing: Fabrication, assembly, installation and wiring diagrams.
   3. Sump Layout Drawings: Detailed layout drawings of each sump showing the locations of the sump pumps to be installed within the sump, pump discharges, and discharge valves.

B. Operation and Maintenance Data: Submit Operations and Maintenance Manuals in accordance with Section 01781, Operations and Maintenance Data.

C. Warranty.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to insure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time not to delay that Work.

B. Handle all sump pumps and appurtenances very carefully. Equipment which is damaged will not be acceptable. Protect all bolt threads, etc. from damage and corrosion.

C. Storage of equipment shall be in accordance with Section 01661, Storage and Protection of Products.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 METER VAULT AND RESIDUALS PUMP ROOM SUMP PUMPS

A. Design Criteria:
   1. Pumps shall be submersible end suction centrifugal. They shall be specially design, constructed, and installed for the service intended and shall comply with the following minimum design conditions:

      Design Conditions:

No. Required	2
Design Flow, gpm	12
Design TDH, Ft.	20
Min. Shutoff TDH, Ft.	23
Minimum Motor Hp	1/3
Minimum Discharge Size, in.	1-1/2
Maximum Speed, rpm	1,550
Maximum Sphere Size, in.	1/2

B. Fabrication:
   1. Pump and Motor:
      a. Pump and motor shall be designed for continuous operation under submergence without leakage.
      b. The pump shall include an all cast iron housing, cover, base, and control chamber.
      c. The motor chambers shall be hermetically sealed against entry of moisture and oil filled. Oil shall be food grade biodegradable.

d. The shaft seal shall be of high quality carbon, stainless steel and Buna-N seal and ceramic seat combination.
e. The impeller shall be enclosed, two-vane.
f. The bearings shall be sleeve type, permanently lubricated.
g. The motor shall be as specified, suitable for operation on 115 volt, single-phase power. The motor shall have built-in overload protection.
h. The power cord shall have a grounding conductor, be 50 feet long, waterproof, oil resistant, and UL approved.
i. Motor shall be non-overloading for the entire pump operating curve.
j. Manufacturer: Provide submersible pumps as manufactured by one of the following:
1) Hydromatic.
2) F. E. Myers.
3) Or equal.

2. Controls:
a. The pump shall be controlled by an integral float switch. The float switch shall be of the mechanical, non-mercury type and be capable of directly controlling the pump motor without the need for an external control panel.
b. All interconnecting cable, conduit, and appurtenances between the pump installation and the panel location shall be furnished by the pump manufacturer.

C. Painting:
1. Pumps, motors, appurtenances, etc., shall receive manufacturer's standard finish paint system prior to shipment.
2. Machined, polished, and non-ferrous surfaces shall be coated with corrosion prevention compound.
3. Field Painting: Refer to Section 09910, Painting.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect and verify that structures or surfaces on which the equipment will be installed have no defects which would adversely affect the installation.

B. The CONTRACTOR shall promptly report, in writing, defects which may affect the Work to the ENGINEER. A copy of the manufacturer’s field report shall be provided to the ENGINEER.

3.2 INSTALLATION

A. Install pumps and piping in a manner and to the tolerances recommended by the

equipment manufacturer.

B. Discharge piping and valves shall be supported independent of pump.

C. Set level switches in accordance with elevations shown on the Drawings. If no elevations are indicated, request information from ENGINEER.

D. All anchor bolts, nuts and other fasteners required for the connection of the equipment and other miscellaneous items to the concrete structure or base pads shall be furnished by the equipment manufacturer. Anchorage items shall conform to the applicable requirements of this Section and of Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

E. All anchoring and connecting hardware shall be 304 stainless steel.

3.3 START-UP AND FIELD TEST

A. Perform operating tests to demonstrate that the equipment operates in the manner intended.

B. Make adjustments required to place equipment in proper operating condition.

3.4 MANUFACTURER'S FIELD SERVICES

A. Field Services: Retain a factory trained manufacturer's representative with demonstrated ability and experience in the installation and operation of the equipment included herein to perform the services listed below:
   1. Supervise the installation.
   2. Test, calibrate and adjust all components for optimum performance.
   3. Assist in initial start-up and field testing.
   4. Inspect the completed installation and prepare an inspection and performance test report.
   5. Instruct OWNER'S personnel in the operation and user maintenance of all components.
   6. Supervise the correction of any defective or faulty work before and after acceptance by OWNER.

+ + END OF SECTION + +

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SECTION 11211

WATER SAMPLE PUMP

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Furnish all labor, materials, equipment, and services for manufacturing, assembling, delivering, installing, testing, and placing in service all pumping equipment including pumps, motors, bases, and appurtenances.

   2. Unless otherwise specified, the pump manufacturer shall furnish each pumping unit complete with drive motor and all other components and shall be held entirely responsible for the compatibility in all respects of all components furnished. Pumping units shall be as specified herein, and shown on the Drawings.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the Water Sample Pump.

C. Related Sections
   1. Section 01330, Submittal Procedures
   2. Section 01781, Operations & Maintenance Data
   3. Division 5, Metals
   4. Section 09910, Painting
   5. Division 15, Mechanical
   6. Division 16, Electrical

1.2 DEFINITIONS

A. When the term "pumping unit" is used hereinafter, it shall be deemed to mean a pump or pumps, complete with, but not limited to, drive motor, connecting shafting, bearings, couplings, accessories, appurtenances, and all associated equipment.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. All pumping units shall be provided by a single manufacturer with a minimum of five (5) year's experience in designing and manufacturing pumping equipment of similar type, size and capacity.

2. Quality Assurance: All pumping units shall be of approved design and products shall be from manufacturers who have built equipment of similar type, size and capacity.
3. Additional Submittals: The Contractor shall submit, upon request, any additional information that the Engineer may deem necessary to determine the ability of the proposed manufacturer to produce the specified equipment.
4. Pumping units shall be the products of manufacturers who can produce evidence of their ability to promptly furnish any and all interchangeable replacement parts as many be needed at any time within the expected life of the pumps. Upon request, the Contractor shall submit full details of the proposed manufacturer's ability to promptly fill replacement orders.
5. Disqualification of Manufacturer:
    a. Failure to successfully comply with the provisions of subparagraphs A through D, inclusive, will constitute grounds for disqualification of pump manufacturer.
    b. Poor performance of similar pumping equipment now in operation under the specified conditions of service and pump rating constitute grounds for disqualification of the pump manufacturer, supplier, or both, unless such poor performance has been corrected.

1. 4 SUBMITTALS

A. Shop Drawings;
1. The Contractor shall comply with the provisions of the Specification 01330, Submittal Procedures regarding submittals, unless otherwise specified herein.
2. Content:
    a. Descriptive Literature:
        1) Dimensions
        2) Materials of Construction (including required coating)
        3) Performance Data
            a) Size of Pump
            b) GPM
            c) TDH
            d) BHP
            e) RPM
            f) Bowl Performance Curves Showing Pump efficiencies
            g) NPSH Curve (if applicable)
            h) Shutoff Head
            i) Rated HP of Motor
            j) Weight of Pump
            k) Weight of Motor
            l) Motor Voltage, full load amperage, service factor, efficiencies and power factors for 25%, 50%, 75%, 100% loads.
    b. Installation Information:

1) Submit drawings and information necessary for final design of foundations, connecting piping and valves, pump drip and drainage piping, electrical connections, starting, speed regulating and protective equipment, and auxiliary equipment.
2) Submit details for mechanical seal assemblies.
3) Submit drawings showing locations, size and full details of foundation bolts for all components for all pumping units.
4) For all pumping units, a dimensioned and scaled assembly outline drawing or drawings of the complete pump, drive, and all associated equipment furnished shall be submitted for approval. Such drawing or drawings shall show plan, elevation, and any other views or sections requested.
5) For all pumping units, a scaled cross-sectional drawing of the assembled pump showing full details and materials of construction shall be submitted for approval.
6) The Contractor shall submit all other drawings, material lists and other information specified, requested and/or necessary to show complete compliance with all details of the Contract Documents.

3. At the time of submission, the Contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

B. Closeout Submittals:
1. Operations and Maintenance Data:
a. Manual shall contain all information necessary for proper operation and maintenance of pumping units, as well as the location of the nearest permanent service headquarters.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in material or workmanship within specified warranty period.
1. Warranty Period for Equipment: Manufacturer's standard, but not less than 1 year from date of Substantial Completion."

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

A. Design Criteria:

1.	Type	-	Horizontal, centrifugal, closed-Coupled, end-suction
2.	Pump casing & seal plate	-	Cast Iron, back pullout design
3.	Impeller	-	Silicone Bronze

4. Bearings - Permanently lubricated ball bearings designed for continuous operation
5. Shaft - 416 Stainless Steel
6. Seal - Mechanical seal with carbon/ceramic faces, BUNA elastomers, 300 series stainless steel single coil spring
7. End Connections - Suction: Raw=1.25", Settled=1/2", Finished=1.25" Discharge: Raw=1", Settled=1/4", Finished=1"
8. Size - HP 75 Series
9. Motor size (hp) - 3/4
10. Sample Line Color - Light Blue
11. Flow (Raw Water Pump) - 7 GPM
12. Head (Raw Water Pump) - 35'
13. Flow (Settled Water Pump) - 7 GPM
14. Head (Settled Water Pump) - 25'
15. Flow (Finished Water Pump) - 7 GPM
16. Head (Finished Water Pump) - 42'
17. Motor: Close-coupled design with TEFC enclosure, NEMA standard, suitable for 120-volt, single phase, 60-Hz ac power supply, in accordance with Division 16 Electrical.
18. Identification Nameplate: Each piece of equipment shall be provided with a substantial nameplate, securely fastened in place and clearly inscribed with the manufacturer's name, year of manufacturer, serial number, and principal rating data.

2.2 MANUFACTURERS

A. Manufacturers: Provide product of one of the following:
   1. Price Pump
   2. Approved Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sample Pump:
   1. All equipment shall be installed in accordance with the manufacturer's recommendations.
   2. This service shall be for the purposes of check-out, initial start-up certification, and instruction of plant personnel.
   3. A written report covering the technician's findings and installation approval shall be submitted to the Engineer covering all inspections and outlining in detail any deficiencies noted.

3.2 FIELD QUALITY CONTROL

A. Site Tests:

1. The field tests shall be made by the Contractor in the presence of and as directed by the CCA. Testing shall be performed in accordance with the manufacturer's recommendations and at a minimum shall include running each pump to insure the rate of flow corresponds to the design rate as specified above.

2. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.

++ END OF SECTION ++

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SECTION 11221

VERTICAL TURBINE FLOCCULATION EQUIPMENT

PART 1- GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and services required to furnish, install and place into service the vertical turbine flocculation equipment as shown on the Drawings and specified herein. The equipment shall be supplied with, but not limited to, electric motor, gear reducer, shaft, and impeller assembly. Entire assembly shall be mounted on steel support structure as indicated.
   2. Variable Frequency Drive (VFD) units shall be furnished by the Contractor in accordance with the Bid Form and Specification Section 16446 requirements.

B. Coordination:
   1. Review installation procedures under other sections and coordinate the installation of items that must be installed with, or before, the Vertical Turbine Flocculation equipment.

C. Related Sections:
   1. Section 01330, Submittal Procedures.
   2. Section 03300, Cast-In-Place Concrete.
   3. Division 16, Electrical and Electrical Contract Drawings.
   4. Section 09910, Painting.
   5. Section 01781, Operations and Maintenance Data.

1.2 REFERENCES

A. Standards referenced in this section are:
   1. American Society for Testing and Materials (ASTM) Publications
   2. Anti-Friction Bearing Manufacturers Association (AFBMA)
   3. American Gear Manufacturers Association (AGMA)
   4. American National Standards Institute (ANSI) Standards
   5. Occupational Safety and Health Administration (OSHA) Standards

1.3 SUBMITTALS

A. Shop Drawings & Product Information:
   1. Descriptive Literature, catalog cuts, and dimensional prints clearly indicating all dimensions and materials of construction, shall be submitted

on all items specified herein.

2. At the time of submission, the contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in material or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than 1 year from date of Substantial Completion.

PART 2- PRODUCTS

2.1 SYSTEM PERFORMANCE

A. General:

1. # Vertical Turbines per Tank:	1 (4 units total)
Overall Basin Dimensions:	22' x 22' x 19.5'
Liquid Level:	18'
Volume:	65,170 gallons
Minimum Velocity Gradient:	80(1/sec)
Maximum Horsepower:	5
Maximum Speed:	1800 RPM
Material of Wetted Parts:	316 Stainless Steel
Impeller Type	3 Bladed Hydrofoil 39 º Root Angle
Maximum Output Speed:	25 RPM
Impeller Off Bottom Spacing:	104"
Minimum Shaft Diameter:	2.5"

B. Gear Drive Type:
   1. The speed reducer shall be suitable for 24-hr/day continuous operation in an outdoor environment. The mechanical rating of the speed reducer shall be at least 1.5 times the motor nameplate horsepower at full speed. The speed reducer shall bear and AGMA nameplate. The thermal rating of the speed reducer shall exceed the design mechanical rating to eliminate the need for external cooling. External cooling devices are not allowed.
   2. General maintenance, specifically including replacement of tank sealing devices, all anti-friction bearings, all oil seals and lubricant maintenance shall not require removal of the speed reducer housing from its foundation. The speed reducer shall have ductile iron housing, integral mounting plate and be provided with lifting lugs.

C. Gears:
   1. All drives shall be parallel shaft, single or double reduction helical gear combination to ensure maximum efficiency coupled with the convenience of mounting, maintenance, and installation. All gearing shall be AGMA Quality 10 as a minimum. Worm gears, belt and/or chain drives are not acceptable.
   2. The gearing shall be designed to withstand normal and shock loads that are transmitted to the gear drive from the agitator lower shaft and impeller assembly. Since gear drives of this design are not protected from this type of loading, it is required that they are designed to withstand it. Commercially available gear drives that are design on torque without evaluation of the mixing loads are not acceptable.

D. Low Speed Output Shaft:
   1. The low speed output shaft will be of hollow quill construction and will accept either English or Metric lower agitator shafts.

E. Dry Well:
   1. The low speed output shaft shall incorporate a sealed dry well design. Open dry well designs will not be acceptable. This dry well seal must prevent oil leakage along the drive output shaft if incidental overfill, i.e., standing waves due to excessive vibration and /or tipping during maintenance, occurs. The top surface of the dry well shall be sufficiently above the dynamic oil level of the gear drive.

F. Lubrication
   1. The speed reducer shall be lubricated with synthetic oil with an oil level such that at least 90% or the gear box volume contains oil. All gearing must be immersed completely in lubricant. The lubrication system shall allow a maximum mixer-mounting angle of 10 degrees from horizontal. Oil pumps will not be allowed. The lubrication shall be such that start-up in highly variable climates, or extremely cold climates, shall require no priming, heaters, or other special effort or equipment.
   2. A single oil drain shall be provided at the low point of the speed reducer to allow oil drainage and leave a maximum residual of oil of no more than ¼" in the drive housing.
   3. Oil changes following the initial run-in period shall not be required at less than one-year intervals. Oil leakage down the low speed output shaft shall be prevented by means of a drywell. No oil seals shall be permitted below the operating oil level for rotating elements. The speed reducer breather shall be located above possible oil foam level.
   4. All gear and bearings shall be protected from rusting during storage by the application of shop-applied protective coating.

G. Bearings:
   1. All reducer bearings shall be Timken taper roller anti-friction type, shall be

oil lubricated and shall be submerged in the lubrication oil to ensure positive lubrication.

2. Gear drive low speed shaft bearings shall have a minimum L10 life of 100,000 hours. All low speed tapered roller bearings must be indirectly mounted. All other bearings shall be of the size and type that is appropriate give the torsional, thrust and lateral loads encountered. The output shaft bearings shall be sized based on the actual (not the average) thrust, and bending loads generated by the agitator shaft and impeller(s) assembly.

H. Mixer Shaft:

1. The output shaft shall be totally overhung; the use of submerged or steady bearings is not permitted. When turned over by hand, impeller shaft run out or deflection shall not exceed ¼" per 10' of length.

I. Shaft to Drive Attachment:

1. The mixer shaft shall be connected to the output shaft of the speed reducer by means of a split removable coupling accessible from outside the tank and located above the reducer. The rigid coupling shall be designed to minimize run out to less than ¼" per 10' of shaft length. Designs, which require a coupling below the speed reducer, are not acceptable.

J. Critical Speed:

1. When stabilizing devices are used in conjunction with mixing impellers, the rotating speed of the unit shall not exceed 80% of the first natural frequency, in air, of the shaft and impeller assembly. The rotational speed shall not exceed 50% for the LIGHTNIN A510 impeller or 40% for any other impeller of the natural frequency when impellers operate for prolonged periods at or near the liquid surface or when impellers without stabilizing devices are used.

K. Impellers:

1. General: Impellers whose power consumption, side load, and pumping characteristics have not been fully documented by the equipment manufacturer will not be acceptable. Such impeller data shall include the affects of liquid level variation on power investment, basin hydraulic stability, blade loading, and process performance.

2. Impeller Construction:

a. The impeller shall be a three bladed high-efficiency, axial flow turbine, producing the specified pumping capacity with a minimum of turbulence as characterized by a relatively uniform velocity profile across the entire diameter of the impeller. The impeller shall meet all of the process parameter detailed in Section 2.1 of this specification. Impeller blades will be bolted to a keyed hub to the shaft. The impeller blades shall have twist and have camber, which decreases from tip to root. The blades shall minimize inefficient localized

turbulence on the backside of the blade by being set at an angle close to, but not exceeding, the point at which flow separation occurs.

b. Because obtaining the correct process result is dependent upon achieving proper flow at minimum shear levels, qualified equipment suppliers shall submit certified test data to demonstrate that the proposed equipment meets the specified flow, power, tip speed and other process requirements.

c. Laboratory test data shall include fluid velocity measurements taken across the impeller's swept diameter and the calculations required for flow calculation. If laboratory data is submitted using a geometrically similar impeller, a minimum of 20 velocity measurements along the radius shall be supplied. Velocity measurements using a non-intrusive measuring device such as a Laser-Doppler velocimeter are preferred. No corrections for instrument interference will be permitted. Data submittal shall include a full description of the test methods, procedures, and instrumentation.

d. In the absence of certified test data acceptable to the engineer, full-scale test data of the equipment proposed for supply shall be provided. The data shall include the primary flow within the circumference of the impeller measured not more than 0.2 diameter below the impeller. Electrical power consumption and the exact impeller rpm during the test shall also be reported. Testing shall be in accordance with the A.I.Ch.E procedure, Method for Evaluating Mixing Equipment, Impeller Type; 2nd. Edition. The test method specifics shall be submitted and are subject to approval by the engineer.

3. Vibration: The impeller shall be of such design, and operate at such rotational speed that dynamic balancing is not required to prevent damaging vibration.

4. Impeller Attachment and Adjustment: Impellers shall be removable from the shaft by means of detachable blades. Impellers shall be connected to the shaft by a square hook type key, designed to transmit full motor torque and to support the impeller assembly on the shaft. An extended keyway shall be provided of sufficient length to permit adjustment of the axial position 18 inches up in three-inch increments from the design location.

5. Materials: Materials of the impeller shafts, impeller hubs and blades hall be as 316 stainless steel. The minimum material thickness form impeller fabrication is 1/8 inch.

L. Motor:

1. The electric drive motor shall be connected to the speed reducer through a flexible coupling. The standard NEMA C-Frame 230/460v, 60Hz, 3-phase vertical motor shall be of "cast iron construction" with cast iron fan cover, diagonally split conduit box, drip cover, and be of an enclosure as specified. The motor insulation shall be Class "F" and the motor shall have a 1.15 service factor. Motor bearings shall be grease lubricated, re-greasable or sealed. The connection between the motor output shaft and the reducer input shaft is to be made by a torsionally resilient flexible coupling suitable

for the loads associated with Variable Frequency Drive operation. This is a Falk Steelflex or equivalent.

2.2 MANUFACTURERS

A. Manufacturer: Provide one of the following:
   1. Philadelphia Mixing Solutions Limited (PMSL) Palmyra, PA
      a. 3800 series mixer drive
   2. Lightnin Mixers, Rochester, NY
      a. 70 series
   3. Approved Equal

2.3 CONTROLS

A. Provide variable frequency drive (VFD) with the following features and in accordance with Section 16446, Variable Frequency Drives:
   1. VFD shall be housed in a wall mount NEMA 12 rated painted steel enclosure constructed in accordance with Section 13430, Control Panel Enclosures and Section 13440 Panel Mounted Instruments.
   2. Provide the following front panel devices on the control panel:
      a. VFD fault amber LED push-to-test indicating light.
      b. Running green LED push-to-test indicating light.
      c. In remote white LED push-to-test indicating light
      d. Elapsed run time indicating meter
      e. VFD/PLC selector switch
      f. Start pushbutton
      g. Stop pushbutton
      h. Speed setpoint potentiometer
      i. Human machine interface (HIM) keypad
      j. Reset pushbutton
   3. Provide the following inputs to the system:
      a. Discrete inputs:
         1. Start/stop signal (from plant PLC)
         2. In remote (from LCS selector switch)
         3. Start/stop signal (from LCS start and stop pushbutton)
      b. Analog inputs:
         1. Speed setpoint (from plant PLC)
   4. Provide the following outputs to the system:
      a. Discrete outputs:
         1. VFD fault (to LCS indicating light)
         2. Running (to LCS indicating light)
         5. VFD Fault (to plant PLC)
         6. In Remote (to plant PLC)
         7. Running (to plant PLC)
      b. Analog outputs:
         1. Speed feedback (to plant PLC)

5. Functional Description
    a. Local control:
        1. When the local-off-remote (LOR) selector switch at the local control station (LCS) is in the local position, the mixer shall be operated by the start and stop pushbuttons at the local control station. The speed shall be adjusted by the potentiometer at the VFD.
        2. When the LOR selector switch at the LCS is in the off position, the mixer shall not run.
    b. Remote Control
        1. When the LOR selector switch at the LCS is in the remote position and the VFD/PLC selector switch at the VFD is in the VFD position, the mixer shall be operated from the start and stop pushbuttons at the VFD. The speed shall be adjusted by the potentiometer at at VFD.
        2. When the LOR selector switch at the LCS is in the remote position and the VFD/PLC selector switch at the VFD is in the PLC position, the mixer shall be operated from the start and stop input to the VFD. The speed shall be adjusted by the speed setpoint signal.
    c. Upon receiving any of the following inputs, the system shall shutdown, latch the alarm (unless otherwise indicated), illuminate the appropriate indicating light, and close the dry contact output. Upon clearing the alarm condition and resetting the system via the reset pushbutton, the system shall be ready again for operation
        1. VFD fault

2.4 FINISHING

A. Painting
    1. Painting shall be as specified in Section 09910 or as a minimum all structural steel shall be sandblasted per SSPC-SP-10 and receive a shop coat of Tnemec Series 1 PurplePrime. Touch up and final coats after installation shall be by the contractor. Drive assemblies are furnished with the manufacturer's standard finish paint.

PART 3- EXECUTION

3.1 INSTALLATION

A. General:
    1. Install in accordance with Manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

A. Site Tests & Manufacturer's Services:
   1. The Contractor shall include with his bid the services of the Equipment Manufacturer's field service technician.
   2. This service shall be for the purposes of check-out, initial start-up certification, and instruction of plant personnel.
   3. A written report covering the technician's findings and installation approval shall be submitted to the Engineer covering all inspections and outlining in detail any deficiencies noted.

++ END OF SECTION ++

SECTION 11225

SEDIMENTATION BASIN EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope of Work:
   1. Provide all labor, materials, equipment and service required to furnish, install, start-up and place in operation the circular scraper type collection equipment.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the Sedimentation Basin Equipment.

C. Related Sections:
   1. Section 03300, Cast-In-Place Concrete
   2. Division 16, Electrical Work and Electrical Contract Drawings.
   3. Section 01330, Submittal Procedures
   4. Section 03600, Precision Grouting
   5. Section 09910, Painting
   6. Section 06600, Fiberglass Reinforced Plastic Products and Fabrications

1.2 SUBMITTALS

A. Shop Drawings and Product Information:
   1. Descriptive literature, catalog cuts, dimension prints, shop drawings, installation, operation and maintenance instructions shall be submitted to the Engineer for review before shipment. The data shown on the shop drawings shall be complete with respect to dimensions, materials of construction, wiring diagrams, and the like, to enable the Engineer to review the information as required.
   2. At the time of submission, the Contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. The manufacturers bidding this equipment shall verify to the General Contractor during bidding and subsequently to the Owner, as part of the shop

drawing review and approval that they have designed, fabricated and placed in service a minimum of four (4) machines at four (4) separate installations. The machines must be similar in size, design, and function. Standard scraper type or flocculator – clarifiers will not be accepted as equal for this purpose.

2. The Contractor shall guarantee and warrant that the equipment furnished and installed is free from defects of design, material and workmanship, and will operate satisfactorily. In the event the equipment fails to perform as specified, and after the Owner has given due notice, the Contractor or Supplier, at their own expanse, shall promptly repair or replace the defective equipment without any additional cost to the Owner.

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in material or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less the 1 year from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 SYSTEM PERFORMANCE

A. General:
   1. Under this item the Equipment Manufacturer shall furnish and deliver circular gravity thickener suitable for installation in two (2) settling tanks, 38 ft. Wide x 38 ft. Long x 23 ft. average water depth.

B. Gravity Thickener Mechanism:
   1. The gravity thickener mechanism shall be supported with side feed and peripheral overflow, as required with plate settlers.
   2. The drive mechanism shall support and rotate a torque tube, to which are attached two (2) structural steel rake arms.
   3. The structural steel bridge shall span the tank diameter and shall support the entire thickener mechanism. The mechanism shall be designed so there shall be no filed welding required, except for the bridge splice, if required.

C. Structural Members
   1. Structural steel to conform to ASTM A36.
   2. Structural steel components shall have minimum thickness of 1/4".
   3. All welding to conform to American Welding Society Standard AWS D1.1. Structural support members shall be shop welded for bolted field assembly. Field welding shall be limited to bridge splices and tack welding of skimmer connections after final positioning.
   4. Components shall be designed so that stresses developed do not exceed

allowable stresses, as defined by current AISC standards, when designed for 120% of the AGMA rated torque.

5. Panel lengths and member sizes shall be selected such that slenderness ratios do not exceed 200 for compression and 240 for tension. For strength, the controlling member force shall be used to determine member size.
6. Maximum deflection in a span under combined live and dead loads shall not exceed L/360.

D. Drive Mechanism
   1. Drive mechanism consisting of primary and final gear reduction unit.
   2. All components of the drive mechanism shall be designed in accordance with AGMA Standard 6034-A87 (March 1988) "Practice for Enclosed Cylindrical Worm Gear Speed Reducers and Gearmotors", for 24-hour continuous, uniform load duty and 20-year design gear life, based on the AGMA rated torque.
   3. All gearing shall be enclosed in gray cast iron ASTM A-48 Class 40B housings
   4. Fabricated steel housings, exposed gearing and submerged bearings shall not be acceptable.
   5. All bearings shall be designed for a minimum B-10 life of 200,000 hours.
   6. Primary Reduction Unit
      a. Provide commercially available helical heavy-duty gear reducer in a cast housing. All bearings shall be anti-friction type running in oil.
      b. The Primary reduction gear reducer shall drive the final reduction unit through a chain and sprocket arrangement.
      c. The drive chain shall be #80L self-lubricating roller chain and shall be covered with an OSHA approved removable guard of molded polyethylene.
      d. Proper chain tension shall be provided for by an adjustable steel base mounted on the final reduction unit.
      e. Motor shall be totally enclosed, ball bearing type, of ample power for starting and continuously operating the drive mechanism without overloading.
      f. Motor shall conform to NEMA standards and be suitable for operation on 240/480 volt, 3 phase, 60 Hertz current.
   7. Final Reduction
      a. The final reduction worm gear shall be a cut-tooth casting mounted on a replaceable four-point contact ball bearings assembly. The bearing shall be mounted in a housing of high strength cast iron.
      b. A steel torque tube shall be bolted to the gear and supports the scraper mechanism.
      c. The housing shall be provided with an extended journal type torque tube steady bearing to prevent tipping of the gear. The final reduction gear and the anti-friction ball bearings shall run in an oil bath within the final gear reduction housing. The housing shall be effectively

sealed against contaminants by a felt strip. A readily accessible oil filling and level pipe with sight gauge shall be furnished

d. Provide worm gear speed reduction with grease and oil lubricated anti-friction type bearings in cast iron housing securely bolted on the machined top face of the final reduction unit. Worm and shaft shall be a two-piece assembly for ease of maintenance. Cycloidal and planetary gearing shall not be acceptable.
e. Align and maintain accurate centers with the final reduction gearing. Swivel base mounting of the intermediate unit shall not be acceptable.
f. Mount an electro-mechanical overload device on the thrust end of the worm shaft consisting of plate spring assembly, plunger, indicator dial two (2) microswitches (one N.O. and one N.C.) and a terminal block, all enclosed in a weather tight, gray cast iron housing. Amperage metering devices shall not be considered equal to the overload device specified.
g. Microswitches shall be factory set to: (1) sound an alarm when the load on the mechanism reaches 100% of the AGMA torque; and (2) stop the motor when the load reaches 120% of the AGMA torque.
h. Provide a shear pin device, set for 140% of the AGMA torque mounted on the drive end of the worm shaft.
i. A visual torque dial indicator shall be provided and oriented so it may be read from the walkway.
j. Provide oil filling and level pipe along with a drain plug and sight gauge.

8. Provide two independently adjustable torque switches for remote indication of high torque condition and shutdown. Switches shall have SPDT contacts rated 5A at 120VAC

E. Torque Tube and Scraper Arms

1. A steel torque tube shall be bolted to the final reduction gear and shall support two (2) structural steel rake arms.
2. Torque tube shall be of a square cross-section type, and have a minimum of three splices for ease of handling and installation.
3. These sludge collecting arms shall be equipped with scraper blades set and spaced to scrape settled sludge from the tank bottom to a sludge hopper located at the center of the tank. They shall be attached to and rotated by the torque tube.
4. The arms shall be fabricated of structural steel, with a minimum thickness of 1/4", and shall be adequately braced with struts and tie bars. Pickets shall be furnished for attachment to the scraper arms.
5. The blades shall be so spaced that the entire tank bottom is scraped twice for each revolution of the mechanism.
6. Adjustable spring brass squeegees shall be provided for all blades and shall project 1-1/2" below the bottom of the blade

F. Access Bridge, Hand-railing, and Toe Plate

1. An all welded structural steel beam bridge shall span the tank and be supported from the tank walls.
2. The bridge, consisting of two (2) structural steel members, shall be braced to assure rigidity. A 3' wide walkway, consisting of fiberglass reinforced plastic panels shall be provided running from one end to the drive assembly. A double handrail, consisting of 2" x 2" x .156", square tube manufactured by the pultrusion process for the rails and vertical posts, and a kickplate that is 4" x ½" (corrugated) x 125" thick pultruded fiberglass shape shall be furnished for both sides of the walkway.
3. The bridge shall be designed to support, in addition to the dead load, a live load of 150# lineal foot of walkway, without deflection in excess of 1/360 of the span.
4. Provide a minimum 9' x 8' rectangular Service platform to provide working clearance around the drive.

G. Anchor Bolts
1. All equipment anchor bolts shall be Type 316 stainless steel, furnished by Equipment manufacturer and of ample size and strength for the specified purpose. All anchor bolts shall be set by the General Contractor in accordance with equipment manufacturer's instructions.
2. Equipment manufacturer shall furnish steel template and grout shield to accurately locate center pier anchors and allow for grouting beneath the pier and manifold seal plate after final plumbing.

2.2 MANUFACTURERS

A. Manufacturer: Provide the following:
1. Siemens Water Technologies
2. DBS Manufacturing
3. Or Approved equal

B. Design Criteria:
1. Hydraulics shall be designed to handle (per basin):

	MAX.
Flow (MGD)	6.00
Solids Loading Rate (gpm/ft^2)	0.34

2. Drive:
   a. Ball race diameter: 17 inch
   b. Motor Horsepower: 0.5 HP.
   c. AGMA rated torque: 12,900 ft-lbs.
   d. Speed: 0.04 RPM.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. General:
   1. All equipment specified in this section shall be installed in accordance with the manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

A. Site Tests: Manufacturer's Services:
   1. A factory trained representative of the manufacturer shall visit the project site to perform installation assistance, start-up, check out and initial operation, and to instruct the plant operating personnel in the operation and maintenance of the equipment. This service shall be for a minimum period of two (2) full working days at the project site. Visits shall be a minimum of two (2) trips, one (1) during the installation, and one (1) after the equipment is ready for operation.
   2. Additional days of on-site service, if required, shall be furnished by the equipment manufacturer on a per diem basis to be borne by the Contractor.

++ END OF SECTION ++

SECTION 11228

INCLINED PLATE SETTLERS

PART I GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified and required to design, furnish, and install all inclined plate settlers with integrated side baffles, flow control deck, collection launders, support structures, end baffles, inlet diffusers, mounting brackets, anchor bolts and fasteners, and related appurtenances. This equipment shall be provided as an integral package by a single manufacturer who shall take responsibility for coordination of all components to assure proper functioning of the sedimentation equipment as a system.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the Inclined Plate Settlers.

C. Related Sections:
   1. Section 01330, Submittal Procedure.
   2. Section 01781, Operations & Maintenance Data.
   3. Section 03330, Cast-In-Place Concrete.
   4. Division 5, Metals.
   5. Section 11225, Sedimentation Basin Equipment Rectangular.
   6. Section 11221, Vertical Turbine Flocculation Equipment.

1.2 REFERENCES

A. Standards referenced in this section are:
   1. American Society for Testing and Materials (ASTM)
   2. ASTM A167 – Type 304L & 316L Stainless Steel
   3. American National Standards Institute (ANSI)
   4. American Welding Society (AWS)

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer shall have been in continuous business for a period of at least 10 years, engaged in the manufacture of water treatment equipment for

municipalities. Said manufacturer shall have at least 10 years experience in the design and building of high rate laminar flow clarification equipment.

2. Prior to bid each manufacturer must provide a list of at least ten (10) installations of all stainless steel plate settlers used in municipal applications installed in the last 5 years along with names and phone numbers of references to be contacted. A list of FRP plate installations will not be acceptable.
3. Manufacturer must provide a certificate of NSF standard 61 certification of the proposed stainless steel inclined plate settlers. NSF approval on the material by itself is not acceptable. Said certificate must accompany the manufacturer's bid package to the contractor before bid opening.
4. Any manufacturer bidding alternate un-named items of equipment shall provide a written indemnification against patent infringement to the owner.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Detailed drawings showing layout including inlet arrangement (baffles/infusers), plates effluent launders, weirs, and support structures shall be submitted to the Engineer for review before shipment. The data shown on the shop drawings shall be complete with respect to dimensions, materials of construction, and the like, to enable the Engineer to review the information as required.
   2. At the time of submission, the Contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

B. Product Information:
   1. Submit manufactures catalogs, literature, and engineering data for the Inclined Plate Settlers and appurtenances. The engineering data shall include design velocities including inlet velocity, velocity at inlet infusers, velocity through plates, velocities at flow control points at top of plates and at inlet to trough and velocities in trough.
   2. Head loss calculation through plate settling units at maximum/average design flow.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Plates shall be factory installed in the frame, and shall be shipped as one plate pack assembly. All equipment shall be shipped with the suitable in transit protection. Special handling instructions shall be included.
   2. Plate packs shall be shipped on flat bed trucks to allow access by crane provide by the contractor.

3. If access by crane to the basins is not possible, then the plate settlers shall be shipped as a pack which can be disassembled for individual component installation.
4. Conform to Engineers Specification Section 01651 & Section 01661.
5. **Once in place the plate settlers must be thoroughly covered until building and roof construction is complete.**

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in material or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than 1 year from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 SYSTEM PERFORMANCE

A. General:
   1. See Table below:

Service	24hr
Number of Basins	2
Inside Basin Width (ft)	38
Inside Basin Length (ft)	38
Side Water Depth (ft)	23
Minimum Flow (MGD) per Basin	2
Design Flow (MGD) per Basin	6
Peak Hydraulic Flow (MGD) per Basin	12
Minimum Effective Projected Horizontal Surface Area (ft^2) per Basin	12,254
Minimum number of plates per Basin	600
Design Loading Rate (gpm/ft^2)	0.34 gpm/ft^2
Plate Efficiency *(Ten State Standard)*	80%
Minimum parallel distance between plates	2-inches
Plate Inclination Measured form the Horizontal	55 degrees
Plate Width (ft)	4.5
*Plate Length (ft)	10
Raw Water Characteristics Prior To Flocculation	
Temperature, Fahrenheit	33-90
Turbidity, NTU	5-1,000
pH	5.5 – 8.0

2. The inclined plate settler system shall comprise the following elements:
    a. Stainless steel plates and frames with integral side baffles.
    b. Stainless steel effluent collection troughs with adjustable weirs.
    c. Stainless steel end baffles.
    d. Stainless steel Inlet infusers.
    f. Stainless steel support beams which span the basin to support the ends of the plate packs. Said beams shall be provided by the manufacture of the plate settlers.
    g. All wall mounted brackets as required.

B. Inlet System
    1. The plate manufacture shall provide an effective inlet diffusion system to reduce the velocity to less than .5 ft. per second when entering the feed flumes of the plate settlers.
    2. The inlet velocity shall not exceed 2 ft. /second in order to prevent floc damage.

C. Plates
    1. The plate settling units shall operate in counter-current mode with clarified water flowing upward while settled solids move down.
    2. The plates shall be arranged in packs. The packs shall be installed on cross beams provided by the manufacturer.
    3. The incoming water shall be fed near the lower end of the plate from the side to allow the settled solids to fall to the floor of the basin while minimizing re-entrainment by the incoming flow.
    4. The plates shall be inclined at an angle of 55° from the horizontal. The plate settlers shall have no moving parts.
    5. The effluent flow at the top of the plate shall be removed in at least four (4) points to insure even distribution across the full width of the plate. Plate settlers with less than four (4) take off points per plate are not acceptable.
    6. The plates shall be removable individually for inspection or repair and to ease initial installation. No structures or troughs shall be required to be removed in order to extract the plates. The effluent troughs shall be located to the side of the plate rows.
    7. The individual lamella plates shall be constructed of flat stainless steel. For plates provided with a top tubular support structure and integral bent sides and bottom framing elements, the plates shall be 24 gauge (0.024 inch thick) minimum. For plates without such integral support, the plates shall be 22 gauge (0.0292 inch thick) minimum. Corrugated sheets will not be acceptable.
    8. The plate packs shall be self supporting and shall not exceed the maximum allowable deflection limits stipulated below.
    9. The plate settlers shall be designed so that an operator may walk out onto the plates at any time, even during operation, without the need to remove

any components. The entire top of each plate settler must be visible for inspection. Local OSHA regulations should be followed.

10. The plates shall be designed structurally for the following conditions:

a. Loading of 30 lbs. per plate live load.

b. A maximum deflection of 1/360 for all structures, troughs, etc.

c. A concentrated load of 250 lbs. anywhere on the flow deck (top tubes) or top edge of plates.

D. Effluent Collection Troughs

1. The effluent troughs shall be located to the side of the plate rows. Troughs located over the plate settlers obstructing access to the tops of the plates will not be accepted.
2. The effluent collection troughs shall be manufactured of T-316 stainless steel. All brackets trough supports, reinforcing sections, stiffeners, flanges, weirs and fasteners shall be of T-316 stainless steel.

E. Structural Support System Requirements

1. The manufacturer of the plate settlers shall provide stainless steel beams to support the plate settler packs to insure compatibility.
2. Support frames and beams shall be adequately sized to carry the load of the plate settling system under both wet and dry conditions without exceeding a maximum deflection of L/360 of the span.
3. The manufacturer will be required to coordinate the structural details of the design with the engineer. This will be required to determine the final location of beams through wall openings, sludge collection mechanism and other design details which may affect the supply of structural support components.

2.2 MANUFACTURERS

A. Manufacturer: Provide one of the following:

1. Meurer Research, Inc. of Golden, Colorado.
2. Jim Myers & Sons, Inc. (JMS), of Charlotte, NC.
3. Approved Equal

2.3 MATERIALS

A. The components of the Inclined Plate Settlers shall be made from the following:

1. Plate Settler Frames: Type 304L SS (Type 316L SS if located at or within 4-inches of the air-water interface)
2. Plates: Type 304L SS (Type 316 L SS if located at or within 4-inches of the air-water interface)
3. Integral Frame Baffles: Type 316L SS (Minimum 11 gauge)
4. Top Flow Control Device: Type 304L SS (Type 316L SS if located within 4-inches of the air-water interface)
5. Tough/Flume Assembly: Type 316L SS (Minimum 14 gauge thick)

6. Adjustable V-notch Weirs: Type 316 SS (Minimum 14 gauge thick)
7. Nuts, bolts, fasteners 316 SS

PART 3- EXECUTION

3.1 INSTALLATION

A. General:
   1. The Contractor shall install the inclined plate settler equipment in strict accordance with the manufacturer's recommendations.
   2. Install and level the plate pack units and troughs in accordance with the manufacturer's recommendations and the Drawings. All plate settler support's anchor locations shall be leveled to within +/- 1/8 of an inch. Exercise care in erecting and leveling the plate settlers, troughs, and weir plates so that the units are at the elevations shown on the Drawings or specified herein and have deflections within manufacturer's specified limits.
   3. After installation, all v-notch weirs must be leveled to within 1/16 of an inch of target elevation as shown on manufacturer's drawings.
   4. Anti-seize thread lubricant, which is NSF-61 approved, shall be applied to the male threads of all stainless steel bolts at the time of the assembly.

3.2 FIELD QUALITY CONTROL

A. Site Tests & Manufacturer's Services:
   1. A factory trained manufacturer's representative shall be provided for a minimum of two (2) trips and a minimum of three (3) eight hour days to provide installation supervision, start-up and field testing services, and O&M training services. The installation services shall be coordinated between the CONTRACTOR and the manufacturer. The start-up and field testing services, and the O&M services shall be coordinated with the ENGINEER.
   2. After installation supervision and field testing services by the manufacturer, the CONTRACTOR shall submit to the ENGINEER, a certification letter on the manufacturer's letterhead and signed by the manufacturer certifying that the equipment was installed per the manufacturer's recommendations.
   3. The manufacturer shall provide start-up reports covering installation inspection and start up activities.
   4. The manufacturer shall provide operator training to all required plant personnel.
   5. A written report covering the technician's findings and installation approval shall be submitted to the Engineer covering all inspections and outlining in detail any deficiencies noted.
   6. All costs, including travel, lodging, meals and incidentals for manufacturer service shall be included in the CONTRACTOR'S bid

++ END OF SECTION ++

SECTION 11242

MECHANICAL FLASH MIXERS

PART 1- GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and services required to furnish, install and place into service the mechanical flash mixers as shown on the Drawings and specified herein. The flash mixer shall be supplied with, but not limited to, electric motor, gear reducer, shaft, and impeller assembly. Entire assembly shall be mounted on steel support structure as indicated.
   2. Variable Frequency Drive (VFD) units shall be furnished by the Contractor in accordance with the Bid Form and specification Section 16446 requirements.

B. Coordination:
   2. Review installation procedures under other sections and coordinate the installation of items that must be installed with, or before, the Mechanical Flash Mixers.

C. Related Sections:
   1. Section 01330, Submittal Procedures.
   2. Section 03300, Cast-In-Place Concrete.
   3. Division 16, Electrical and Electrical Contract Drawings.
   4. Section 09910, Painting.
   5. Section 01781, Operations and Maintenance Data.

1.2 REFERENCES

A. Standards referenced in this section are:
   1. American Society for Testing and Materials (ASTM) Publications
   2. Anti-Friction Bearing Manufacturers Association (AFBMA)
   3. American Gear Manufacturers Association (AGMA)
   4. American National Standards Institute (ANSI) Standards
   5. Occupational Safety and Health Administration (OSHA) Standards

1.3 SUBMITTALS

A. Shop Drawings & Product Information:
   1. Descriptive Literature, catalog cuts, and dimensional prints clearly indicating all dimensions and materials of construction, shall be submitted on all items specified herein.

2. At the time of submission, the contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in material or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than 1 year from date of Substantial Completion.

PART 2- PRODUCTS

2.1 SYSTEM PERFORMANCE

A. General:

1. Overall Basin Dimensions:	4'-6"W x 4'-6" L x 8'-6" d
Liquid Level:	6'-6"
Number of Units:	2 units (installed in series)
Maximum Horsepower:	10
Maximum Speed:	1800 RPM
Impeller Minimum Dia:	25"
Maximum Output Speed:	155 RPM
Minimum Flow:	4.5 MGD
Maximum Flow:	12 MGD

B. Gear Drive Type:
   1. The speed reducer shall be suitable for 24-hr/day continuous operation in an outdoor environment. The mechanical rating of the speed reducer shall be at least 1.5 times the motor nameplate horsepower at full speed. The speed reducer shall bear and AGMA nameplate. The thermal rating of the speed reducer shall exceed the design mechanical rating to eliminate the need for external cooling. External cooling devices are not allowed.
   2. General maintenance, specifically including replacement of tank sealing devices, all anti-friction bearings, all oil seals and lubricant maintenance shall not require removal of the speed reducer housing from its foundation. The speed reducer shall have ductile iron housing, integral mounting plate and be provided with lifting lugs.

C. Gears:
   1. All drives shall be parallel shaft, single or double reduction helical gear combination to ensure maximum efficiency coupled with the convenience of mounting, maintenance, and installation. All gearing shall be AGMA

Quality 10 as a minimum. Worm gears, belt and/or chain drives are not acceptable.

2. The gearing shall be designed to withstand normal and shock loads that are transmitted to the gear drive from the agitator lower shaft and impeller assembly. Since gear drives of this design are not protected from this type of loading, it is required that they are designed to withstand it. Commercially available gear drives that are design on torque without evaluation of the mixing loads are not acceptable.

D. Low Speed Output Shaft:
   1. The low speed output shaft will be of hollow quill construction and will accept either English or Metric lower agitator shafts.

E. Dry Well:
   1. The low speed output shaft shall incorporate a sealed dry well design. Open dry well designs will not be acceptable. This dry well seal must prevent oil leakage along the drive output shaft if incidental overfill, i.e., standing waves due to excessive vibration and /or tipping during maintenance, occurs. The top surface of the dry well shall be sufficiently above the dynamic oil level of the gear drive.

F. Lubrication
   1. The speed reducer shall be lubricated with synthetic oil with an oil level such that at least 90% or the gear box volume contains oil. All gearing must be immersed completely in lubricant. The lubrication system shall allow a maximum mixer-mounting angle of 10 degrees from horizontal. Oil pumps will not be allowed. The lubrication shall be such that start-up in highly variable climates, or extremely cold climates, shall require no priming, heaters, or other special effort or equipment.
   2. A single oil drain shall be provided at the low point of the speed reducer to allow oil drainage and leave a maximum residual of oil of no more than ¼" in the drive housing.
   3. Oil changes following the initial run-in period shall not be required at less than one-year intervals. Oil leakage down the low speed output shaft shall be prevented by means of a drywell. No oil seals shall be permitted below the operating oil level for rotating elements. The speed reducer breather shall be located above possible oil foam level.
   4. All gear and bearings shall be protected from rusting during storage by the application of shop-applied protective coating.

G. Bearings:
   1. All reducer bearings shall be Timken taper roller anti-friction type, shall be oil lubricated and shall be submerged in the lubrication oil to ensure positive lubrication.
   2. Gear drive low speed shaft bearings shall have a minimum L10 life of 100,000 hours. All low speed tapered roller bearings must be indirectly

mounted. All other bearings shall be of the size and type that is appropriate give the torsional, thrust and lateral loads encountered. The output shaft bearings shall be sized based on the actual (not the average) thrust, and bending loads generated by the agitator shaft and impeller(s) assembly.

H. Mixer Shaft:
   1. The output shaft shall be totally overhung; the use of submerged or steady bearings is not permitted. When turned over by hand, impeller shaft run out or deflection shall not exceed ¼" per 10' of length.

I. Shaft to Drive Attachment:
   1. The mixer shaft shall be connected to the output shaft of the speed reducer by means of a split removable coupling accessible from outside the tank and located above the reducer. The rigid coupling shall be designed to minimize run out to less than ¼" per 10' of shaft length. Designs, which require a coupling below the speed reducer, are not acceptable.

J. Critical Speed:
   1. When stabilizing devices are used in conjunction with mixing impellers, the rotating speed of the unit shall not exceed 80% of the first natural frequency, in air, of the shaft and impeller assembly. The rotational speed shall not exceed 50% for the LIGHTNIN A510 impeller or 40% for any other impeller of the natural frequency when impellers operate for prolonged periods at or near the liquid surface or when impellers without stabilizing devices are used.

K. Impellers:
   1. General: Impellers whose power consumption, side load, and pumping characteristics have not been fully documented by the equipment manufacturer will not be acceptable. Such impeller data shall include the affects of liquid level variation on power investment, basin hydraulic stability, blade loading, and process performance.
   2. Impeller Construction:
      a. The impeller shall be a three bladed high-efficiency, axial flow turbine, producing the specified pumping capacity with a minimum of turbulence as characterized by a relatively uniform velocity profile across the entire diameter of the impeller. The impeller shall meet all of the process parameter detailed in Section 2.1 of this specification. Impeller blades will be bolted to a keyed hub to the shaft. The impeller blades shall have twist and have camber, which decreases from tip to root. The blades shall minimize inefficient localized turbulence on the backside of the blade by being set at an angle close to, but not exceeding, the point at which flow separation occurs.
      b. Because obtaining the correct process result is dependent upon achieving proper flow at minimum shear levels, qualified equipment suppliers shall submit certified test data to demonstrate that the

proposed equipment meets the specified flow, power, tip speed and other process requirements.

c. Laboratory test data shall include fluid velocity measurements taken across the impeller's swept diameter and the calculations required for flow calculation. If laboratory data is submitted using a geometrically similar impeller, a minimum of 20 velocity measurements along the radius shall be supplied. Velocity measurements using a non-intrusive measuring device such as a Laser-Doppler velocimeter are preferred. No corrections for instrument interference will be permitted. Data submittal shall include a full description of the test methods, procedures, and instrumentation.

d. In the absence of certified test data acceptable to the engineer, full-scale test data of the equipment proposed for supply shall be provided. The data shall include the primary flow within the circumference of the impeller measured not more than 0.2 diameter below the impeller. Electrical power consumption and the exact impeller rpm during the test shall also be reported. Testing shall be in accordance with the A.I.Ch.E procedure, Method for Evaluating Mixing Equipment, Impeller Type; 2nd. Edition. The test method specifics shall be submitted and are subject to approval by the engineer.

3. Vibration: The impeller shall be of such design, and operate at such rotational speed that dynamic balancing is not required to prevent damaging vibration.

4. Impeller Attachment and Adjustment: Impellers shall be removable from the shaft by means of detachable blades. Impellers shall be connected to the shaft by a square hook type key, designed to transmit full motor torque and to support the impeller assembly on the shaft. An extended keyway shall be provided of sufficient length to permit adjustment of the axial position 18 inches up in three-inch increments from the design location.

5. Materials: Materials of the impeller shafts, impeller hubs and blades hall be as 316 stainless steel. The minimum material thickness form impeller fabrication is 1/8 inch.

L. Motor:

1. The electric drive motor shall be connected to the speed reducer through a flexible coupling. The standard NEMA C-Frame 230/460v, 60Hz, 3-phase vertical motor shall be of "cast iron construction" with cast iron fan cover, diagonally split conduit box, drip cover, and be of an enclosure as specified. The motor insulation shall be Class "F" and the motor shall have a 1.15 service factor. Motor bearings shall be grease lubricated, re-greasable or sealed. The connection between the motor output shaft and the reducer input shaft is to be made by a torsionally resilient flexible coupling suitable for the loads associated with Variable Frequency Drive operation. This is a Falk Steelflex or equivalent.

2.2 MANUFACTURERS

A. Manufacturer: Provide one of the following:
   1. Philadelphia Mixing Solutions Limited (PMSL) Palmyra, PA
      a. 3800 series mixer drive
   2. Lightnin Mixers, Rochester, NY
      a. 70 series
   3. Approved Equal

2.3 FINISHING

A. Painting
   1. Painting shall be as specified in Section 09910 or as a minimum all structural steel shall be sandblasted per SSPC-SP-10 and receive a shop coat of Tnemec Series 1 Purple Prime. Touch up and final coats after installation shall be by the contractor. Drive assemblies are furnished with the manufacturer's standard finish paint.

PART 3- EXECUTION

3.1 INSTALLATION

A. General:
   1. Install in accordance with Manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

A. Site Tests & Manufacturer's Services:
   1. The Contractor shall include with his bid the services of the Equipment Manufacturer's field service technician.
   2. This service shall be for the purposes of check-out, initial start-up certification, and instruction of plant personnel.
   3. A written report covering the technician's findings and installation approval shall be submitted to the Engineer covering all inspections and outlining in detail any deficiencies noted.

++ END OF SECTION ++

SECTION 11280

SLUICE GATES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope of Work:
   1. Sluice gates shall be furnished with all necessary accessories for a complete installation, including but not limited to, operating stems, stem guides and actuators.

B. Coordination:
   1. Review installation procedures under other sections and coordinate the installation of items that must be installed with, or before, the Sluice Gates.

C. Related Work Specified Elsewhere:
   1. Section 01330, Submittal Procedures
   2. Section 01781, Operations & Maintenance Data
   3. Division 3, Concrete

1.2 SUBMITTALS

A. Shop Drawings and Product Information:
   1. Descriptive literature, catalog cuts, and dimensional prints clearly indicating all dimensions and materials of construction, shall be submitted on all items specified herein.
   2. At the time of submission, the contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

1.3 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in material or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than 1 year from date of Substantial Completion."

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

A. General:
   1. Leakage: Sluice gates shall be substantially watertight under the design head conditions. Leakage shall not exceed 0.05 U.S. gallons per minute per foot (0.012 l/min per meter) of periphery under the design seating head and 0.10 U.S. gallons per minute per foot (0.025 l/min per meter) of periphery for an unseating head of 30 feet (9 m).
   2. Design Head: The sluice gates shall be designed to withstand a head of 30 feet (9 meters), unless otherwise specified.

B. Sluice Gates:
   1. General Design: Gates shall be either self-contained or non self-contained of the rising stem configuration as indicated on the gate schedule.
      a. Gates shall consist of a frame on which are mounted the rails and a movable slide.
   2. Wall Thimble: The wall thimble shall be stainless steel and supplied by the gate manufacturer. Refer to the gate schedule for type and applicable locations. Material thickness should be per manufacturer's recommendations.
   3. Frame: The gate frame shall be made of structural members or formed plate welded to form a rigid one- piece frame. The frame shall be of the flange back design and allow mounting directly on a concrete wall (CW) or a wall thimble (WT). The seating face of the frame shall be at an angle to the plane of the mounting flange. The frame shall support at least two thirds (2/3) of the vertical height of the slide in the fully open position.
   4. Slide: The slide shall consist of a flat plate reinforced with formed plates or structural members to limit its deflection to 1/720 of the span of the gate under the design head.
   5. Guides and Seals: The side and top seals shall be of the self-adjusting type and constructed of UHMWPE. A continuous compression cord shall ensure contact between the UHMWPE guide and the gate in all positions.

C. Operators and Stem:
   1. Stem and Couplings: The operating stem shall be of stainless steel designed to transmit in compression at least 2 times the rated output of the operating manual mechanism with a 40 lbs (178 N) effort on the crank or handwheel.
      a. The stem shall have a slenderness ratio (L/r) less than 200. The threaded portion of the stem shall have machine cut threads of the Acme type.
      b. Where a hydraulic, pneumatic or electric operator is used, the stem design force shall not be less than 1.25 times the output thrust of the hydraulic or pneumatic cylinder with a pressure equal to the maximum working pressure of the supply, or 1.25 times the output thrust of the electric motor in the stalled condition.
   2. For stems in more than one piece and with a diameter of 1 ¾ inches (45 mm) and larger, the different sections shall be joined together by solid bronze couplings. Stems with a diameter smaller than 1 ¾ inches (45 mm) shall be pinned to an

extension tube.

a. The couplings shall be grooved and keyed and shall be of greater strength than the stem.

3. Gates having a width equal to or greater than two times their height shall be provided with two lifting mechanisms connected by a tandem shaft.
4. Stem Guides: Stem guides shall be fabricated from stainless steel. The guide shall be equipped with UHMWPE bushings. Guides shall be adjustable and spaced in accordance with the manufacturer's recommendation to limit the L/r ratio to less than 200.
5. Stem Cover: Rising stem gates shall be provided with a clear PVC stem cover. The stem cover shall have a cap and condensation vents and a clear mylar position indicating tape. The tape shall be field applied to the stem cover after the gate has been installed and positioned.
6. Lifting Mechanism: Manual operators of the types listed in the schedule shall be provided by the gate manufacturer.
   a. All bearings and gears shall be totally enclosed in a weather tight housing. The pinion shaft of crank-operated mechanisms shall be constructed of stainless steel and supported by roller or needle bearings.
   b. Each manual operator shall be designed to operate the gate under the maximum specified seating and unseating heads by using a maximum effort of 40 lbs (178 N) on the crank or handwheel, and shall be able to withstand, without damage, an effort of 80 lbs (356 N).
   c. The crank shall be removable and fitted with a corrosion-resistant rotating handle. The maximum crank radius shall be 15 inches (381 mm) and the maximum handwheel diameter shall be 24 inches (610 mm).
7. Yoke: Self-contained gates shall be provided with a yoke made of structural members or formed plates. The maximum deflection of the yoke shall be 1/360 of the gate's span.

D. Crank Operated Floor Stands:
   1. The geared floor stand shall have a weatherproof, cast iron housing, with a bronze operating nut, mounted on a high strength pedestal. The operating nut shall be internally threaded with 29 degree acme threads corresponding to stem threading.
   2. Tapered roller bearings shall be located above and below the bronze operating nut to support the output thrust of the floor stand.
   3. The gearing shall be accurately cut and of proper design to support the load conditions without undue stress.
   4. The stainless steel pinion shaft will be mounted on tapered roller bearings to provide low friction operation and to resist axial and radial thrusts.
   5. Mechanical seals shall be provided around the operating nut and the pinion shaft to prevent lubrication from leaving the unit and moisture from entering the sealed housing.
   6. The reduction gear case shall be precision machined and equipped with tapered roller or needle bearings and sealed about the reduction shafts.

7. Lubrication fittings shall be provided for all bearings.
8. Crank operated floor stands shall be selected so that no more than 40 lbs. Effort on the crank will be required to open or close the sluice gate.

2.2 MANUFACTURERS

A. Manufacturer: Provide one of the following:
   1. Rodney Hunt Company, Orange, Massachusetts.
   2. Fontaine USA, Inc., Bedford, NH
   3. Approved equal.

2.3 MATERIALS

A. General:
   1. See Table Below:

PART	MATERIAL
Frame, yoke, stem guides, slide, stem extension, rails	Stainless steel ASTM A-240 type 304L or 316L
Guide bar	Ultra high molecular weight polyethylene (UHMWPE) ASTM D-4020
Top and side seals	EPDM ASTM D2000-01 BA910 C12 and ASTM D2000-01 BA415
Bottom seal	Neoprene ASTM D2000 M2 BC 503
Threaded stem	Stainless steel ASTM A-276 type 303 MX or 316
Fasteners	ASTM F593 and F594 GR1 for type 304 and GR2 for type 316
Pedestal, handwheel and crank	Tenzaloy aluminum
Gasket (between frame and wall)	EPDM ASTM 1056
Stem cover	Polycarbonate ASTM D-3935
Lift nut, couplings	Manganese bronze ASTM B584 UNS-C86500

PART 3 - EXECUTION

3.1 INSTALLATION

A. Scope:
   1. The installation of all parts shall be done by the Contractor in a workmanlike manner and in accordance with detailed technical installation procedures supplied by the gate manufacturer. It shall be the Contractor's responsibility to

handle, store and install the gate operating mechanism and accessories in strict accordance with the manufacturer's drawings and recommendations.

3.2 FIELD QUALITY CONTROL

A. Field Tests
   1. Following the completion of each gate installation, the gates shall be operated through at least two complete open/close cycles. If an electric or hydraulic operator is used, limit switches shall be adjusted following the manufacturer's instructions.

   2. Gates should be checked for leakage by the contractor (refer to Section 2.1.A "System Performance" section for approval criteria).

3.3 SCHEDULES

A. General:
   1. See Table Below:

SLUICE GATE SCHEDULE

Location/Purpose	Size (W x H)	Quantity	Operator Type
Flocculation Stage Control	4'-6" x 3'-0"	4	Manual Handwheel

++ END OF SECTION ++

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SECTION 11285

SLIDE GATES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope of Work:
   1. Gates shall be furnished with all necessary accessories for a complete installation and shall be the latest standard products of a manufacturer regularly engaged in the production of equipment of this type. All slide gates shall be furnished by the same manufacturer.

B. Coordination:
   1. Review installation procedures under other sections and coordinate the installation of items that must be installed with, or before, the Slide Gates.

C. Related Sections:
   1. Section 01330, Submittal Procedure.
   2. Section 01781, Operations & Maintenance Data.
   3. Division 3, Concrete.

1.2 SUBMITTALS

A. Shop Drawings - Prudent Information:
   1. Descriptive literature, catalog cuts, and dimensions\al prints clearly indicating all dimensions and materials of construction, shall be submitted on all items specified herein.
   2. At the time of submission, the Contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

1.3 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in material or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than 1 year from date of Substantial Completion."

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

A. General:
   1. Leakage: Slide gates shall be substantially watertight under the design head conditions. Leakage shall not exceed 0.05 U.S. gallons per minute per foot (0.012 l/min per meter) of periphery under the design seating head and 0.05 U.S. gallons per minute per foot (0.025 l/min per meter) of periphery for an unseating head of 30 feet (9 m).
   2. Design Head: The sluice gates shall be designed to withstand a head of 30 feet (9 meters), unless otherwise specified.

B. Slide Gates:
   1. General Design: Gates shall be either self-contained or non self-contained of the rising stem configuration as indicated on the gate schedule.
      a. Gates shall consist of a frame on which are mounted the rails and a movable slide.
   2. Frame: The gate frame shall be made of structural members or formed plate welded to form a rigid one- piece frame. The frame shall be of the flange back design and allow mounting directly on a concrete wall (CW) The seating face of the frame shall be at an angle to the plane of the mounting flange. The frame shall support at least two thirds (2/3) of the vertical height of the slide in the fully open position.
   3. Slide: The slide shall consist of a flat plate reinforced with formed plates or structural members to limit its deflection to 1/720 of the span of the gate under the design head.
   4. Guides and Seals: Side seals shall be of the self-adjusting type and constructed of UHMWPE. A continuous compression cord shall ensure contact between the UHMWPE guide and the gate in all positions.

C. Operators and Stem:
   1. Stem and Couplings: The operating stem shall be of stainless steel designed to transmit in compression at least 2 times the rated output of the operating manual mechanism with a 40 lbs (178 N) effort on the crank or handwheel.
      a. The stem shall have a slenderness ratio (L/r) less than 200. The threaded portion of the stem shall have machine cut threads of the Acme type.
      b. Where a hydraulic, pneumatic or electric operator is used, the stem design force shall not be less than 1.25 times the output thrust of the hydraulic or pneumatic cylinder with a pressure equal to the maximum working pressure of the supply, or 1.25 times the output thrust of the electric motor in the stalled condition.
   2. For stems in more than one piece and with a diameter of 1 ¾ inches (45 mm) and larger, the different sections shall be joined together by solid bronze couplings. Stems with a diameter smaller than 1 ¾ inches (45 mm) shall be

pinned to an extension tube.

a. The couplings shall be grooved and keyed and shall be of greater strength than the stem.

3. Gates having a width equal to or greater than two times their height shall be provided with two lifting mechanisms connected by a tandem shaft.
4. Stem Guides: Stem guides shall be fabricated from stainless steel. The guide shall be equipped with UHMWPE bushings. Guides shall be adjustable and spaced in accordance with the manufacturer's recommendation to limit the L/r ratio to less than 200.
5. Stem Cover: Rising stem gates shall be provided with a clear PVC stem cover. The stem cover shall have a cap and condensation vents and a clear mylar position indicating tape. The tape shall be field applied to the stem cover after the gate has been installed and positioned.
6. Lifting Mechanism: Manual operators of the types listed in the schedule shall be provided by the gate manufacturer.
   a. All bearings and gears shall be totally enclosed in a weather tight housing. The pinion shaft of crank-operated mechanisms shall be constructed of stainless steel and supported by roller or needle bearings.
   b. Each manual operator shall be designed to operate the gate under the maximum specified seating and unseating heads by using a maximum effort of 40 lbs (178 N) on the crank or handwheel, and shall be able to withstand, without damage, an effort of 80 lbs (356 N).
   c. The crank shall be removable and fitted with a corrosion-resistant rotating handle. The maximum crank radius shall be 15 inches (381 mm) and the maximum handwheel diameter shall be 24 inches (610 mm).
7. Yoke: Self-contained gates shall be provided with a yoke made of structural members or formed plates. The maximum deflection of the yoke shall be 1/360 of the gate's span.

D. Crank Operated Floor Stands:
   1. The geared floor stand shall have a weatherproof, cast iron housing, with a bronze operating nut, mounted on a high strength pedestal. The operating nut shall be internally threaded with 29 degree acme threads corresponding to stem threading.
   2.. Tapered roller bearings shall be located above and below the bronze operating nut to support the output thrust of the floor stand.
   3. The gearing shall be accurately cut and of proper design to support the load conditions without undue stress.
   4. The stainless steel pinion shaft will be mounted on tapered roller bearings to provide low friction operation and to resist axial and radial thrusts.
   5. Mechanical seals shall be provided around the operating nut and the pinion shaft to prevent lubrication from leaving the unit and moisture from entering the sealed housing.
   6. The reduction gear case shall be precision machined and equipped with tapered roller or needle bearings and sealed about the reduction shafts.

7. Lubrication fittings shall be provided for all bearings.
8. Crank operated floor stands shall be selected so that no more than 40 lbs. Effort on the crank will be required to open or close the sluice gate.

2.2 MANUFACTURERS

A. Manufacturers Recommended:
   1. Rodney Hunt Company, Orange, Massachusetts.
   2. Fontaine USA, Inc. Bedford, NH.
   3. Approved equal.

2.3 MATERIALS

A. General:
   1. See Table Below:

Materials for the gate shall be as follows:

Part	**Material**
Frame, Yoke, Stem Guide, Slide, Stem Extension	Stainless Steel ASTM A-276, Type 304L
Side Seals, Stem Guide Liner	UHMWPE ASTM D-4020
Bottom seal	Neoprene ASTM D-2000, Grade 2 BC-510
Compression cord	Nitrile ASTM D-2000 M6BG 708, A14, B14, EO14, EO34
Threaded stem	Stainless Steel ASTM A-276, Type 303 MX
Fasteners	ASTM F593 and F594, GR1 for Type 304 and GR2 for Type 316
Pedestal, Handwheel, Crank	Tenzaloy aluminum
Gasket (between frame and wall)	EPDM ASTM 1056
Stem Cover	Polycarbonate ASTM A-707
Lift Nut	Manganese bronze ASTM B584 Alloy 432

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. The installation of all parts shall be done by the Contractor in a workmanlike manner and in accordance with detailed technical installation procedures supplied by the gate manufacturer. It shall be the Contractor's responsibility to handle, store and install the gate operating mechanism and accessories in strict accordance with the manufacturer's drawings and recommendations.

3.2 FIELD QUALITY CONTROL

A. Field Tests
   1. Following the completion of each gate installation, the gates shall be operated through at least two complete open/close cycles. If an electric or hydraulic operator is used, limit switches shall be adjusted following the manufacturer's instructions.

   2. Gates should be checked for leakage by the contractor (refer to Section 2.1.A "System Performance" section for approval criteria).

3.2 SCHEDULES

A. General:
   1. See Table Below:

SLIDE GATE SCHEDULE

Location/Purpose	Size (W x H)	Quantity	Operator Type
Flocculation Influent Channel	4'-6" x 3'-0"	2	Manual Handwheel
Flocculation Effluent Channel	4'-6" x 3'-0"	2	Manual Handwheel
Filter Overflow Structure	8'-0" x 4'-0"	1	Manual Handwheel
Sedimentation Influent Channel	1'-3" x 2'-0"	8	Manual Handwheel

++ END OF SECTION ++

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SECTION 11900

GRANULAR ACTIVATED CARBON PRESSURE VESSEL SYSTEMS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall hire the granular activated carbon (GAC) pressure vessel system manufacturer to provide all labor, materials, equipment, incidentals, and services as shown, specified, and required to furnish, install, backwash, test, and startup GAC pressure vessels filled with specified GAC, complete with piping and appurtenances, configured as shown on the Drawings. The GAC pressure vessel system shall include the following:
      a. Pressure vessel construction.
      b. Pressure vessel manway access.
      c. Pressure vessel maintenance access, ladders and platforms.
      d. Pressure vessel ports and nozzles.
      e. Pressure vessel coating/lining and paint.
      f. Underdrain collection system.
      g. Process, utility, and GAC transfer piping: All piping connected to branch of tees on 4-tier manifold shall not be included in the GAC pressure vessel system.
      h. Process, utility, and GAC transfer valves: All valves located on piping connected to branch of tees on 4-tier manifold shall not be included in the GAC pressure vessel system.
      i. Transfer hose connectors.
      j. Spare transfer hoses.
      k. Flush connections.
      l. Pressure/air relief valves and piping.
      m. Pressure gauges.
      n. Differential pressure transmitters and sensors.
      o. Pressure vessel sampling ports.
      p. Flow meters.
      q. Process valve actuators.
      r. Pressure Valve System:
   2. CONTRACTOR shall be completely responsible for the proper start-up, operation and functions of the GAC herein specified. CONTRACTOR shall be responsible for coordination of all interfaces with other sub-contractors, GAC pressure vessel system manufacturers and GAC suppliers to achieve the required operation.

B. Related Sections:
   a. Division 1, General Requirements.

b. Section 09900, Painting.
c. Section 13220, GAC Media.
d. Section 13453, DeviceNet.
e. Division 15, Mechanical.

1.2 REFERENCES

A. Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
1. Standards of the Hydraulic Institute.
2. National Electric Code.
3. American National Standards Institute.
4. American Society of Mechanical Engineers
5. ANSI/ NSF International Standards
6. American Water Works Association (AWWA) Standards
7. International Building Code
8. International Mechanical Code
9. Uniform Plumbing Code

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer shall have a minimum of five years experience manufacturing GAC pressure vessels for municipal drinking water treatment. The manufacturer shall show evidence of at least one installation in satisfactory operation for the 40,000 pound size similar in scope to the application specified herein. The manufacturer shall also show evidence of at least four installations in satisfactory operation for the 20,000 or 30,000 pound size similar in scope to the application specified herein. The GAC media supplied is specified under Section 13220, GAC Media, and may be supplied by a different manufacturer than the GAC pressure vessel system.

1.4 SUBMITTALS

A. The CONTRACTOR shall submit the following as developed by the manufacturer to the ENGINEER for approval:
1. Dimensioned layout and section drawings showing pressure vessels and all piping, ports, and appurtenances, including GAC supply, GAC treated water, GAC backwash waste/vessel-to-waste, and GAC backwash supply as well as GAC exchange piping and pipe connection locations;
2. System drawings (including dimension and materials of construction) showing the following:
a. Pressure vessel construction.
b. Pressure vessel access.
c. Pressure vessel ports and nozzles.
d. Pressure vessel coating/lining and paint.
e. Normal GAC bed depth and GAC media volume.

f. Available height for bed expansion during backwash.
g. Underdrain collection system.
h. Process, utility, and GAC transfer piping.
i. Process, utility, and GAC transfer valves.
j. Process valve actuators.
k. Flow meters.
l. Transfer hose connectors.
m. Flush connections.
n. Pressure/air relief valve and piping.
o. Pressure gauges.
p. Differential pressure sensor.
q. Pressure vessel ladders and platforms.

3. System weights, including empty pressure vessel weights, pressure vessel weights after installation of GAC, and maximum pressure vessel weights after installation of GAC and filling pressure vessels with water.
4. Cut sheets for valve assemblies, piping, pressure vessel underdrain system, instruments, and other appurtenant items.
5. Equipment list.
6. Hydraulic calculations indicating normal operating pressure range, pressure drop at design flowrate, and required backwash flow, pressure, and maximum backwash pressure drop.
7. Manufacturer's literature for interior lining and exterior coating products.
8. Manufacturer's recommended field installation and anchoring requirements and procedures.
9. Manufacturer's literature indicating design pressure and capacity.
10. Manufacturer's literature for system flow diagram showing all valves, components, instrumentation and utilities.
11. List of recommended spare parts.

B. Operation and maintenance data in accordance with Section 01781.

C. CONTRACTOR shall obtain from the manufacturer and submit to OWNER a certification that the GAC pressure vessels and appurtenances have been installed properly.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery of Materials
1. Comply with the requirements of Section 01651, Transportation and Handling of Products, and Section 01661, Storage and Protection of Products, and supplemental requirements below.
2. CONTRACTOR shall inventory and inspect all equipment upon delivery to the site and repair or replace all equipment discovered missing or damaged.
3. Throughout shipment, all pressure vessel ports and pipe ends shall be sealed with watertight caps or blind flanges/plates that remain in place until installation of the equipment and completion of all piping connections.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Equipment: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 SERVICE CONDITIONS

A. Number of Pressure vessels: 14.

B. Ambient Air Temperature:
   1. 55 degrees F minimum.
   2. 92 degrees F maximum.

C. Water Temperature:
   1. 34 degrees F minimum.
   2. 90 degrees F maximum.

D. Height of GAC Building Access Door: 14 feet.

E. The design water flow rate through each vessel shall be 496 gpm, providing an EBCT of 20 minutes at 10 MGD. The vessels shall also be capable of a water flow rate through each vessel of 595 gpm, providing an EBCT of 17 minutes at 12 MGD. The maximum flow rate through each vessel shall be 700 gpm.

2.2 DETAILS OF CONSTRUCTION

A. General: Provide seven GAC pressure vessel systems with two GAC pressure vessels operated in parallel. Water will enter the pressure vessels via the GAC supply piping and flow downward through the GAC bed. An external header underdrain system shall be provided to collect the treated water and retain the GAC in the bed. The treated water shall be discharged from the pressure vessels through the GAC treated water piping. The GAC pressure vessel system shall include all piping, valves, instrumentation, and all appurtenances needed to provide a complete GAC pressure vessel system as described in Section 1.1.A. The pressure vessels shall be piped with GAC supply, GAC treated water, GAC backwash supply, and GAC backwash waste/vessel-to-waste connections in a four-tier manifold. System piping and valving shall be configured to allow parallel operation of the pressure vessels. The GAC pressure vessel system shall meet the following criteria:

1. Maximum pressure drop across the entire dual-pressure vessel system, including intermediate piping, at the design flow rate: 8 psi.
2. Minimum empty bed contact time (EBCT) per pressure vessel: 20 minutes.
3. Minimum dry GAC weight per pressure vessel: 40,000 lbs.

B. GAC Pressure Vessels: GAC pressure vessels shall be vertical cylindrical pressure vessels 12 feet in diameter with an elliptical top. Straight side lengths shall be sufficient to allow for a minimum of 20% GAC bed expansion during backwash. The pressure vessels shall be designed, constructed, and stamped in accordance with ASME code, Section VIII, for design pressure rating of 125 psig at 140 degrees Fahrenheit. Each pressure vessel shall be constructed of carbon steel and shall have all welds and any other sharp edges ground smooth, and all imperfections such as skip welds, delaminations, scabs, slivers, and slag corrected prior to abrasive blasting. All surfaces shall be degreased prior to sandblasting. The pressure vessels shall be equipped with lifting lugs and support legs suitable for rigging and anchoring the pressure vessels.

C. Pressure Vessel Manway Access: The pressure vessels shall be equipped with two manways sized to accommodate the repair and/or removal of the largest single internal component, as follows. Each manway access shall have permanently marked or mounted safety warnings at all entry locations indicating "CONFINED SPACE".
1. One minimum 20-inch diameter manway located on the top dome of the pressure vessel accessible via the maintenance access platform.
2. One minimum 20-inch diameter manway located on the lower straight side portion of the pressure vessel above the underdrain system.

D. Pressure Vessel Maintenance Access:
1. All pressure vessels, except PV-1N, shall be equipped with a ladder to provide access to the maintenance platform, as follows:
   a) Each ladder shall be provided with a safety cage.
   b) Each ladder shall be sized to provide adequate access to the maintenance platform.
   c) Ladder shall not compromise integrity of vessel and shall not interfere with vessel lining or require any internal welding of the vessel.
   d) Each ladder will be of FRP construction, fire retardant, and with UV inhibitors.
2. All pressure vessels shall be equipped with a maintenance platform to provide access to the manway located on the top dome of the pressure vessel, as follows:
   a) Each maintenance platform shall be equipped with a safety handrail extending the full perimeter of the maintenance platform with the exception of an opening for the ladder. The maintenance platform height shall be determined based on the selected GAC pressure vessel system manufacturer.

b) The maintenance platform shall be sized to accommodate the swing and opening of the manway.
c) Each maintenance platform shall be constructed of FRP construction, fire retardant, and with UV inhibitors.

E. Pressure Vessel Ports and Nozzles: All port and nozzle connections shall be flush on the inside of the shell and provided with 150-pound full face flanges on the outside. Steel flanges shall conform to AWWA C207 for steel ring flanges, Class B. Bolts shall conform to ASTM A 307, Grade A or B. Gaskets shall have full-face, of best quality natural or synthetic rubber, 1/8-inch thick.

F. Pressure Vessel Interior Lining: All surfaces shall be degreased prior to sandblasting. The internal surface of the pressure vessels shall be sand blasted (SSPC-SP5) to a white metal surface to provide a 3 to 4 mil anchor pattern in the metal. The interior of the pressure vessels shall be lined to resist abrasion by GAC and to prevent corrosion that will occur when wet GAC is in contact with carbon steel. Interior pressure vessel lining shall consist of a vinyl ester system with NSF certification for direct contact with drinking water, applied to a dry film thickness range of 35 to 45 mils. Lining product shall be Plasite 4110 by Carboline or equal. Where supports, brackets, clips, and similar items of stainless steel are attached to the interior of the pressure vessels, lining shall extend a minimum of 1 inch onto the backup plate from the pressure vessel wall for immersion service. Manufacturer shall perform a spark test and millage checks to ensure complete coverage of the interior pressure vessel lining.

G. Exterior Shop Painting: The exterior of the pressure vessels shall be sandblasted to a commercial blast cleaning (SSPC-SP6). Following sandblasting of the exterior, a rust inhibitive epoxy primer shall be applied. The finish exterior painting of an epoxy paint for outside service shall be applied to the exterior of the pressure vessel before rust can form beneath the primer coat. The exterior coating color shall be selected by the OWNER. All exterior coating shall consist of the following, or equal:

1. Tnemec coatings:
    a. Primer: Tnemec Series 69-1211 Epoxoline II or equivalent– 1 coat, 2.0 to 3.0 dry mils.
    b. Intermediate: Tnemec 69 H.B. Epoxoline II or equivalent – 1 coat, 3.0 to 5.0 dry mils.
    c. Finish: Tnemec 71 Endura-Shield or equivalent – 1 coat, 1.5 to 2.5 dry mils.
2. Carboline Epoxy Coatings
    a. Primer: Carboline 893 Rust Preventative Epoxy, 3.0 dry mil, minimum.
    b. Finish Coat: Carboline 134 High Solids Urethane, 3.0 dry mil, minimum.

H. Underdrain Collection System: Provide an external GAC steel ring header. Provide eight septa screens. Each septa screen shall be a 316L stainless steel V-wire screen.

I. Process, Utility, and GAC Transfer Piping: The process piping on the pressure vessels shall include GAC supply, GAC treated water, GAC backwash supply, and GAC backwash waste/vessel-to-waste arranged on a four-tier manifold. The GAC supply and GAC treated water pipe network shall allow for parallel operation of the GAC pressure vessel system. The utility piping on the pressure vessel shall include vent lines. The GAC transfer piping shall include GAC fill and GAC drain lines. With the exception of the GAC fill and GAC drain piping, all piping shall be carbon steel piping, as specified below. GAC fill and GAC drain piping to and including the shut-off valve and fittings shall be Type 316L stainless steel. The exterior of the carbon steel piping shall be cleaned to a power tool grade (mechanical grade) and a rust inhibitive alkyd metal primer shall be applied before any rust can form. A finish exterior painting of alkyd resin based paint for outside service must be applied to the exterior of the piping before rust can form beneath the primer coat. Exterior finish paint color for steel pipe and fittings will be selected by the OWNER. Based on pipe size, all piping shall be identified with pipeline identification signs or tags in accordance with Section 15100, Valves and Appurtenances.

1. Process and Utility Piping (GAC supply, GAC treated water, GAC backwash supply, GAC backwash waste/vessel-to-waste, and vent piping) as shown in the Drawings.
   a. Pipe:
      1) Reference, ASTM A 53, Grade B.
      2) Type: Carbon steel pipe.
      3) Weight: Schedule 40.
      4) End Finish: Plain.
   b. Fittings:
      1) Threaded (3 inches and smaller):
         a) Reference: ANSI B16.3.
         b) Type: Malleable iron.
      2) Flanged (4 inches and larger):
         a) Reference: ANSI B16.1, Class 125 or ANSI B16.5, Class 150.
         b) Gaskets:
            (1) Reference: ASTM D 1330, Grade 1.
            (2) Type: Non-asbestos, compressed carbon fiber gasketing with SBR binder, 1/8-inch thick, as manufactured by Garlock Gasket Company, Series HTC 9800, or equal.
         c) Fasteners:
            (1) Reference: ASTM A 193.
            (2) Type: Type 304 stainless steel.
      3). Welded:
         a) Reference: ANSI B16.9.
         b) Type: Butt welded.

2. GAC Transfer Piping and Valves:
    a. Pipe:
        1) Reference, ASTM A778
        2) Type: 316L Stainless Steel Pipe
        3) Weight:
            a) 3 inches and smaller: Schedule 40
            b) 4 inches and larger: Schedule 10
    b. Fittings: ASTM A774
        1) 3 inches and smaller- Threaded Seamless
        2) 4 inches and larger- Inert Gas Welded or Flanged (ANSI 16.1, Class 125)
        3) Flanged Gaskets Same as Steel Pipe
    c. Valves: ANSI 150
        1) Full-bore ball valves
        2) Type: 316 Stainless Steel
        3) Ends: ANSI B16.5 flanged

J. Process and Utility Valves: The process and utility piping, excluding GAC fill and GAC drain piping, shall be equipped with butterfly valves for flow control and isolation purposes.
    1. Butterfly Valves
        a. General:
            1) Provide butterfly valves conforming to AWWA C504 and as specified herein.
            2) Type: Wafer
            3) Rated Working Pressure: 150 psig Class 150B.
            4) Maximum Fluid Temperature: 180 degrees F.
            5) The valves shall provide drip-tight bidirectional shut-off at the rated pressures.
            6) Valve seats shall be mounted in the body.
            7) The valves shall be capable of being held in the open or partially open position for manual operation or for automatic operation. When the disc is so held, there shall be no chatter or vibration of the disc or operating mechanism.
            8) Valve packing shall be replaceable without dismantling the valve.
        b. Materials of Construction: All materials of construction shall conform to AWWA C504 and shall be as follows for various valve components:
            1) Body: Cast iron, ductile iron, or alloy cast iron.
            2) Shaft: Type 316 stainless steel.
            3) Discs:
                a) Valves Smaller than 30 Inch: Cast iron.
            4) Seats: Buna-N or other synthetic rubber suitable for the application.
            5) Seating Surfaces: Type 316 stainless steel.
            6) Bearings:
                a) Valves Smaller than 24 Inch: Nylon.

7) Shaft Seals: Self-adjusting V-type chevron, material same as for seats.
8) Tapered Pins for Attachment of Shaft to Disc: Type 316 stainless steel.
9) All internal and external bolting and other hardware including pins, set screws, studs, bolts, nuts and washers: Type 316 stainless steel.

c. Interior Coating: All valves shall be coated inside. The steel, cast iron and ductile iron surfaces, except machined surfaces, shall be epoxy coated in accordance with AWWA C550.
d. Exterior Painting: Valve bodies and handwheels shall be shop primed and painted according to manufacturer's standards. Exterior finish paint color for valve bodies and handwheels will be selected by the OWNER.
e. Testing: Test all valves in the shop in conformance with AWWA C504.
f. Automatic Gear Actuators for Manual Valves:
1) Provide gear actuators conforming to AWWA C504.
2) Size gear actuators for valves 20 inch and smaller for 150 psi differential pressure and 16 feet per second port velocity.

2. Brass Body Ball Valves:
a. Type: Two piece body with standard port opening.
b. Construction:
1) Body: Brass.
2) Ball: Brass with hard chrome plated finish.
3) Stem: Brass.
4) Stem Packing: PTFE.
5) O-Rings: Viton.
6) Seats: PTFE.
c. Non-blowout stem design.
d. Pressure Rating: Class 125, 400 psi WOG.
e. End Connections: Threaded (sizes 3 inches and smaller).

K. Transfer Hose Connectors: The GAC transfer piping shall be fitted with hose connectors such that GAC transfer to and from the pressure vessels can be facilitated with transfer hoses. These connectors shall be 4-inch quick disconnector adapters constructed of Type 316 stainless steel.

L. Transfer Hoses: Provide two 20 foot length sections of 4-inch flexible transfer hose to facilitate GAC transfers. Hose type and end connections shall be coordinated with GAC supplier and GAC pressure vessel system manufacturer.

M. Flush Connections: Two flush connections shall be provided on each GAC fill line, one upstream and one downstream of the ball valve. One flush connection shall be provided downstream of the shutoff valve. Connections shall be welded into steel pipe or supplied in solid polypropylene "spacers" for lined pipe.

N. Pressure Relief Valves: A pressure relief valve (or air release valve) shall be provided for each pressure vessel with the relief capacity as required by ASME

code as shown on Drawings. The pressure relief shall have a pressure rating of 125 psi at 140 degrees F. Pressure relief valve discharge piping shall be extended from the valve location to within one foot of the pressure vessel foundation.

1. Product and Manufacturer:
    a. Mueller Company.
    b. Watts Regulator.
    c. Or Equal.

O. Air Release Valves: An air release valve (or pressure relief valve) shall be provided for each pressure vessel and shall have a small venting orifice to vent the accumulation of air and other gases with the line or system under pressure.

1. Construction:
    a. Body, Cover: Cast Iron ASTM A 126 Grade B.
    b. Float: Type 316 Stainless Steel ASTM A 240.
    c. Seat: Buna-N or Type 316 Stainless Steel.
    d. Trim: Type 316 Stainless Steel ASTM A 240.
2. Air release valves shall be float operated, compound lever type.
3. Valves shall be suitable for pressures up to 150 psi.
4. Air release valves shall incorporate an isolation valve to allow removal of the valve without shutting down the equipment.
5. Product and Manufacturer: Provide one of the following:
    a. APCO, as manufactured by Valve and Primer Corporation.
    b. Crispin, as manufactured by Multiplex Manufacturing Company.
    c. Or equal.

P. Pressure Gauges: The process piping shall be equipped with pressure gauges as shown on the Drawings. Pressure gauges furnished shall be suitable for their intended use. Unless otherwise shown on the plans or indicated in the special specifications, pressure gauges shall conform with the following requirements:

1. Case: The case shall be cast aluminum, black finish, and water tight.
2. Ring: The ring shall be reinforced polypropylene, black finish, and threaded.
3. Dial Size: The dial size shall be 4-inch or 4.5-inch, nominal.
4. Pressure Range: The pressure range shall be 0-100 psi, in 1/2 psi graduations.
5. Connections: The connection shall be 1/2-inch NPT. The connection shall be stainless steel. A properly rated hydraulic base with hardware for a hose bib connection shall be provided with the gauge.
6. Accuracy: The accuracy of the pressure gauge shall be ½% mid-scale and 1% full scale
7. Pointer Travel: The travel of the gauge pointer shall be greater than 200 degrees and less than 270 degrees.
8. Pressure Sending Element: A Bourdon tube, manufactured of type 316 stainless steel shall be provided.
9. Movement: The pressure gauge shall be provided with a stainless steel or movement.
10. Temperature Range: The operating temperature range of the pressure gauge shall range from 20 degrees to 150 degrees F.

11. Gauge Fill. The gauge shall be filled with glycerin.

Q. Differential Pressure Indicating Transmitter and Sensor:
1. Type: Solid state two-wire transmitter.
2. Function: Differential pressure meter shall be capable of sensing pressure from two sources. The transmitter shall display the monitored differential pressure value and shall output a 4 to 20 mADC signal proportional to the monitored differential pressure.
3. Performance Requirements:
   a) Range: As specified in the Instrument Schedule in Section 13420, Primary Sensors and Field Instruments
   b) Positive Overrange Protection: At least 1. 5 times the maximum span limit.
   c) Local Indication: As specified in the Instrument Schedule
   d) Accuracy (includes combined effects of linearity, hysteresis, and repeatability): ±0.10 percent of calibrated span.
   e) Repeatability: 0.05 percent of calibrated span.
   f) Hysteresis: 0.05 percent of calibrated span.
   g) Stability (drift over a six month period): Not more than ±0.25 percent of transmitter's upper range limit.
   h) Power: Designated to operate on power from receiver or remote power supply, nominal 24 VDC.
   i) Supply Voltage Effect: Output change not greater than 0.005 percent of span for each one volt change in supply power.
   j) Output:
      1) Isolated direct acting 4 to 20 mADC.
      2) Digital process variable signal superimposed on 4 to 20 mADC signal without compromising loop integrity.
   k) Ambient Temperature Limits: -20 to +180 degrees F.
   l) Ambient Temperature Effect (Total Error per 100 degrees F change between the Ambient Temperature Limits): Not more than ±1.0 percent of the transmitter's upper range limit (maximum span).
   m) 5 year runtime warranty.
4. Construction Features:
   a) Measuring elements protected by sealing diaphragm.
   b) Capillary tube: Provide 316 stainless steel. Capillary tube from remote diaphragm seal to five-way 316 stainless steel block and bleed valve mounted to sensor.
   c) Non-Wetted Parts:
      1) Body and Process Connection Bolting: Type 316 stainless steel.
      2) Housing and Cover: Die cast low copper aluminum alloy finished with epoxy paint system; NEMA 4 rating.
   d) Element Type: Dual Diaphragm Seal Type
   e) Process Wetted Parts: To be compatible with the process fluid as indicated in the Instrument Schedule.
   f) Calibration Adjustments:

1) Zero & Span: Manually adjustable, without exposing electrical components via local non intrusive push buttons, and has Hart capability.

g) Zero Elevation and Suppression: The extent that the amount of suppression plus the calibrated span does not exceed the upper range limits of the sensor.
h) Damping: Internal Adjustable.
i) Built-in electrical surge and RFI protection.
j) Electrical Conduit Connection: 1/2-inch NPT.
k) Indicator: Provide integral indicator with range in engineering units.

5. Manufacturer:
   a) Siemens Sitrans P.
   b) Foxboro.
   c) Rosemount.
   d) Or equal.

R. Sampling Ports:
1. Pressure vessels shall be outfitted with 316 stainless steel sampling ports for the GAC supply and GAC treated water from each pressure vessel and for the common combined supply and treated water lines. Sample ports shall include dual Type 316 stainless steel ball valves. Sample port discharge tubing shall be turned downward and piped within 2 ft from grade and the valve shall be no more than 4 ft from grade. CONTRACTOR shall provide brass tags affixed with stainless steel wire to the valves and sample ports on the piping manifold and GAC pressure vessels to be engraved according to ENGINEER'S instructions.
2. Each pressure vessel shall be outfitted with three (3) 2" side sample nozzles for use with in-bed water sample probes. Same probes shall consist of 12" Type 316 stainless steel with a Type 316 stainless steel slotted nozzle to collect a water sample from within the GAC bed. The sample probe will be inserted through a 2" flanged nozzle and will be provided with a drop line and shutoff valve external to the pressure vessel as shown on the DRAWINGS.

S. Pressure Vessel Flow Meters: Provide one of the following:
1. Annubar-type flow meter per GAC pressure vessel where shown on the Drawings. The flow meter shall have a remotely mounted transmitter and manufacturer provided stainless steel impulse lines. Provide Emerson Rosemount 485 Series (Size 2) flow meter. Provide one spare.
2. Insertion-type flow meter per GAC pressure vessel where shown on the Drawings. The flow meter shall have a remotely mounted transmitter and manufacturer provided continuous interface cable. Provide McCrometer Model 385 FPI flow meter. Provide one spare.

T. Pressure Vessel Valve Automatic Actuators: Valve actuator type defined in the valve schedule in Section 15100, Valves and Appurtenances and shown on I-06-604. Coordinate remote valve actuators with I-06-604. All cabling for actuator

controls shall be provided with the GAC pressure vessel valve actuators in accordance with Section 15100, Valves and Appurtenances. The Actuators shall have DeviceNet Communication capability in accordance with Section 13453, DeviceNet.

2.3 PRODUCT AND MANUFACTURER

A. Provide GAC pressure vessels as follows:
   1. Model 12 Modular GAC Adsorption System as manufactured by Calgon Carbon Corporation with specified appurtenances.
   2. HP1240S Liquid Phase Adsorption System as manufactured by Siemens Water Technologies with specified appurtenances.

PART 3 – EXECUTION

3.1 EQUIPMENT INSTALLATION

A. CONTRACTOR shall hire the granular activated carbon (GAC) pressure vessel system manufacturer to install GAC pressure vessels and appurtenances as shown on the DRAWINGS and according to manufacturer's standards and recommendations. Pressure vessels shall be installed level according to manufacturer's recommended tolerances. Each vessel leg shall be provided with an equipment pad as shown on the DRAWINGS.

B. CONTRACTOR shall coordinate and adjust all piping based on GAC pressure vessel equipment actually provided to result in properly positioned connections between pipe fittings supplied with the GAC pressure vessels and yard piping installed by CONTRACTOR. All piping shall be supported independent of the GAC pressure vessels via steel pipe supports that shall be anchored to the concrete equipment foundation or via angular wall supports. General locations shown on DRAWINGS.

C. It is the responsibility of the CONTRACTOR to select the method for installing the GAC pressure vessels in the building during construction.

3.2 CLEANING, PRESSURE TESTING, AND DISINFECTION

A. OWNER will provide potable water supply connection for flushing and disinfection. CONTRACTOR shall be responsible for all piping, hoses, valves, pumps, equipment, chemicals, and bacteriological sampling and testing for cleaning, testing and disinfection. Bacteriological sampling and testing shall be completed according to OWNER's standard procedures.

B. Cleaning: CONTRACTOR shall clean the interior of each GAC pressure vessel by removing all visible dirt and debris that may have entered the GAC pressure vessel during construction/installation. CONTRACTOR shall also flush all piping and valves appurtenant to the GAC pressure vessels with potable water.

C. Hydrostatic Pressure Testing: After cleaning, CONTRACTOR shall pressure test the GAC pressure vessels and appurtenant piping as a system. Test pressure shall be 125 psig for a minimum of two hours, and test shall be conducted in the presence of ENGINEER. All leaks, failures, and malfunctions detected during the testing shall be immediately repaired. Testing shall be repeated until the treatment system can maintain the required pressure for the specified duration without any leakage, failures, or malfunctions. CONTRACTOR shall provide written certification of hydrostatic testing and results to ENGINEER within 24 hours of satisfactory completion of testing.

D. Disinfection: After completion of hydrostatic pressure testing, CONTRACTOR shall disinfect GAC pressure vessels and appurtenant piping in accordance with Section 01453, Cleaning, Testing and Disinfecting Hydraulic Structures.

3.3 GAC MEDIA INSTALLATION

A. GAC media shall be installed in GAC pressure vessels in accordance with Section 13220, GAC Media.

3.4 START-UP AND ACCEPTANCE TESTING

A. After installation of the GAC media in each GAC pressure vessel, the CONTRACTOR, GAC pressure vessel system Manufacturer's factory-trained field representative, and GAC media supplier Manufacturer's factory-trained field representative shall assist OWNER's operating personnel in initial system start-up, including initial operation in the pressure vessel-to-waste and backwashing modes, in accordance with manufacturer's recommendations, for removal of fines from the newly installed GAC beds.

B. When the Manufacturers determine the GAC beds are ready for normal operation, the Manufacturers shall assist OWNER's operating personnel in placing the treatment system in the normal mode of operation.

C. Upon placement of the treatment system in normal mode of operation, an acceptance testing period of 7 days shall commence to demonstrate to the satisfactory operation of the system to OWNER. During the acceptance testing, OWNER will monitor operational parameters, inspect for leaks, and identify any Defective Work. At the completion of the acceptance testing period OWNER will notify CONTRACTOR of any Defective Work observed and corrective action required. CONTRACTOR shall correct Defective Work in accordance with Section 00710, General Conditions.

D. If Defective Work is identified during the initial 7-day acceptance period, an additional 7-day acceptance test will be required after correction of Defective Work by CONTRACTOR. This cycle will repeat until the system completes a 7-day acceptance test to the satisfaction of OWNER.

3.5 MANUFACTURER'S SERVICES

A. The GAC pressure vessel system manufacturer shall inspect the installation prior to testing, disinfection, GAC media installation, and initial start-up. Prior to initial start-up, a written manufacturer's statement shall be provided to the ENGINEER stating that the equipment and GAC media have been installed in accordance with the Drawings, Specifications, and Manufacturer's Shop Drawings, and is the system is ready to be placed into operation.

B. The GAC pressure vessel system manufacturer shall provide and start-up services in accordance with Paragraph 3.4. GAC pressure vessel system manufacturer shall coordinate with the OWNER and the GAC media supplier for installation of the GAC media.

C. The GAC pressure vessel system manufacturer shall provide instruction of OWNER's operation and maintenance personnel in accordance with Section 01821, Instruction of Operations and Maintenance Personnel.

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SECTION 12345

LABORATORY FURNISHINGS AND FIXTURES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Steel casework.
   2. Table frames.
   3. Work surfaces.
   4. Sinks and outlets.
   5. Service fittings.
   6. Accessory equipment.

1.02 CASEWORK DESIGN REQUIREMENTS

A. Flush construction: Surfaces of doors, drawers and panel faces shall align with cabinet fronts without overlap of case ends, top or bottom rails. Horizontal and vertical case shell members (panels, top rails and bottoms) shall meet in the same plane without overlap, cracks or crevices.

B. Slimline styling: Front width of end panels 3/4" and front height of top and bottom members 1".

C. Self-supporting units: Completely welded shell assembly without applied panels at ends, backs or bottoms, so that cases can be used interchangeably or as a single, stand-alone unit.

D. Interior of case units: Easily cleanable, flush interior. Base cabinets, 30" and wider, with double swinging doors shall provide full access to complete interior without center vertical post.

E. Drawers: Sized on a modular basis for interchange to meet varying storage needs, and designed to be easily removable in field without the use of special tools.

F. Case openings: Rabbeted-like joints all four sides of case opening for hinged doors and two sides for sliding doors in order to provide dust resistant case.

G. Framed glazed doors: Identical in construction, hardware and installation to solid panel doors. Design frame glazed doors to be removable for glass replacement.

1.03 CASEWORK PERFORMANCE REQUIREMENTS

A. Structural performance requirements: Casework components shall withstand the following minimum loads without damage to the component or to the casework operation:
   1. Steel base unit load capacity: 500 lbs. per lineal foot.
   2. Suspended units: 300 lbs.
   3. Drawers in a cabinet: 150 lbs.
   4. Utility tables (4 legged): 300 lbs.
   5. Hanging wall cases: 300 lbs.
   6. Load capacity for shelves of base units, wall cases and tall cases: 100 lbs.

B. Metal Finish Performance Requirements:
   1. Abrasion resistance: Maximum weight loss of 5.5 mg. per 100 cycle when tested on a Taber Abrasion Tester #E40101 with 1000 gm wheel pressure and Calibrase #CS10 wheel.
   2. Hardness: Surface hardness equivalent to 4H or 5H pencil.
   3. Humidity resistance: Withstand 1000 hour exposure in saturated humidity at 100 degrees F.
   4. Moisture resistance:
      a. No visible effect to surface finish after boiling water trickled over test panel inclined at 45 degrees for five minutes.
      b. No visible effect to surface finish following 100 hour continuous application of a water soaked cellulose sponge, maintained in a wet condition throughout the test period.
   5. Adhesion: Score finish surface of test panel with razor blade into 100 squares, 1/16" x 1/16", cutting completely through the finish but with minimum penetration of the substrate, and brush away particles with soft brush. Minimum 95 squares shall maintain their finish.
   6. Salt spray: Withstand minimum 200 hour salt spray test.

1.04 SUBMITTALS

A. Shop Drawings: Provide 3/4" = 1'-0" scale elevations of individual and battery of casework units, cross sections, rough-in and anchor placements, tolerances and clearances. Indicate relation of units to surrounding walls, windows, doors and other building components. Provide 1/4" = 1'-0" rough-in plan drawings for coordination with trades. Rough-in shall show free area.

B. Product Data: Submit manufacturer's data for each component and item of laboratory equipment specified. Include component dimensions, configurations, construction details, joint details, and attachments, utility and service requirements and locations.

C. Product Samples Upon Request: Submit for approval:
   1. Top Sample.
   2. Finish Sample (3" X 5" Painted Steel).

D. Finish Samples: Submit 3 x 5 inch samples of each color of finish for casework, work surfaces and for other prefinished equipment and accessories for selection by Owner.

E. Test Reports: When requested by Architect, submit independent laboratory certified test reports verifying conformance to test performance specified.

1.05 QUALITY ASSURANCE

A. Single source responsibility: Casework, work surfaces, laboratory fume hood and equipment and accessories shall be manufactured or furnished by a single laboratory furniture company.

B. Manufacturer's qualifications: Modern plant with proper tools, dies, fixtures and skilled workmen to produce high quality laboratory casework and equipment, and shall meet the following minimum requirements:
   1. Ten years or more experience in manufacture of laboratory casework and equipment of type specified.
   2. Ten installations of equal or larger size and requirements.

C. Installer's qualifications: Factory trained and/or certified by the manufacturer.

D. Cabinet identification: Cabinets are identified on drawings by manufacturer's catalog numbers. Unless otherwise modified on drawings or in specifications, catalog description constitutes specific requirements for each type of cabinet.

1.06 DELIVERY, STORAGE AND HANDLING

A. Schedule delivery of casework and equipment so that spaces are sufficiently complete that material can be installed immediately following delivery.

B. Protect finished surfaces from soiling or damage during handling and installation. Keep covered with polyethylene film or other protective coating.

C. Protect all work surfaces throughout construction period with 1/4" corrugated cardboard completely covering the top and securely taped to edges. Mark cardboard in large lettering "No Standing".

1.07 PROJECT CONDITIONS

A. Do not deliver or install equipment until the following conditions have been met:
   1. Windows and doors are installed and the building is secure and weathertight.
   2. Ceiling, overhead ductwork and lighting are installed.
   3. All painting is completed and floor tile is installed.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Design, materials, construction and finish of casework specified is the minimum acceptable standard of quality for flush front steel laboratory casework. The basis of this specification is Fisher Hamilton Inc., 1316 - 18th Street, Two Rivers, WI 54241 product.

2.02 CASEWORK MATERIALS

A. Sheet steel: Mild, cold rolled and leveled unfinished steel.

B. Minimum gauges:
   1. 20 gauge: Solid door interior panels, drawer fronts, scribing strips, filler panels, enclosures, drawer bodies, shelves, security panels and sloping tops.
   2. 18 gauge: Case tops, ends, bottoms, bases, backs, vertical posts, uprights, glazed door members, door exterior panels and access panels.
   3. 16 gauge: Top front rails, top rear gussets, intermediate horizontal rails, table legs and frames, leg rails and stretchers.
   4. 14 gauge: Drawer suspensions, door and case hinge reinforcements and front corner reinforcements.
   5. 11 gauge: Table leg corner brackets and gussets for leveling screws.

2.03 CASEWORK FABRICATION

A. Base Units and Cases:
   1. Base units and 25", 31" and 37" high wall cases: End panels and back reinforced with internal reinforcing front and rear posts.
   2. 49" and 84" high cases: Formed end panels with front and rear reinforcing post channels; back shall be formed steel panel, recessed 3/4" for mounting purposes.
   3. Posts: Front post fully closed with full height reinforcing upright. Shelf adjustment holes in front and rear posts shall be perfectly aligned for level setting, adjustable to 1/2" o.c.
   4. Secure intersection of case members with spot and arc welds. Provide gusset reinforcement at front corners.
   5. Base unit backs: Provide fixed backs at all drawer and cupboard units. No access to services behind.
   6. Bottoms: Base units and 25", 31", 37" and 49" high wall cases shall have one piece bottom with front edge formed into front rail, rabbeted as required for swinging doors and drawers and flush design for sliding doors.
   7. Top rail for base units: Interlock with end panels, flush with front of unit.
   8. Horizontal intermediate rails: Recessed behind doors and drawer fronts.
   9. Base for base units: 4" high x 3" deep with formed steel base and 11 ga. die formed steel gussets at corners. Provide 3/8" diameter leveling screw with

integral bottom flange of minimum 0.56 sq. in. area at each corner, accessible through openings in toe space.

10. Tops of wall cases: One piece, with front edge formed into front rail.

B. Drawers:
   1. Drawer fronts: 3/4" thick, double wall construction, prepainted prior to assembly and sound deadened.
   2. Drawer bodies: Bottom and sides formed into one-piece center section with bottom and sides coved and formed top edges. Front and back panels spot welded to center section.
   3. Drawer suspension: Heavy duty coved raceways for both case and drawer with nylon tired, ball bearing rollers; self-centering and self-closing when open to within 3" of the closed position.
   4. Provide drawer with rubber bumpers. Friction centering devices are not acceptable.
   5. Provide security panels for drawers with keyed different locks.
   6. File drawers: Provide with 150# full extension slides for full access and operation.

C. Doors:
   1. Solid panel doors: 3/4" thick, double wall, telescoping box steel construction with interior prepainted and sound deadened, top corners welded and ground smooth. Reinforce interior of front panel with welded steel hat channels. Hinges with screws to internal 14 gauge reinforcing in case and door. Hinges shall be removable; welding of hinges not acceptable. Doors shall close against rubber bumpers.

D. Shelves:
   1. Form front and back edges down and back 3/4". Form ends down 3/4".
   2. Reinforce shelves over 36" long with welded hat channel reinforcement the full width of shelf.
   3. Pull out shelves: Same suspension as specified for drawers.

E. Base molding: 4" high, to be furnished and installed by flooring contractor.

F. Corner base guards: 4" high #304 stainless steel corner guards.

G. Hardware:
   1. Drawer and hinged door pulls: Clear anodized extruded aluminum, screw attached on 4" centers.
      a. Pull Location: Horizontal at drawers, vertical at doors.
   2. Hinges: Institutional type, five knuckle projecting barrel hinges, minimum 2-1/2" long, type 302 or 304 stainless steel. Provide two hinges for doors up to 36" high; three hinges for doors over 36" high. Drill each leaf for three screw attachment to door and frame.
   3. Door catches: Adjustable type, spring actuated nylon roller catches.

4. Elbow catches: Spring type of cadmium plated steel, with strike of suitable design.
5. Locks: National Lock Remove-A-Core 5-disc tumbler, heavy duty cylinder type. Exposed lock noses shall be dull nickel (satin) plated and stamped with identifying numbers.
6. Keying: Locks shall have capacity for 225 primary key changes. Master key one level with the potential of 40 different, non-interchangeable master key groups
7. Keys: Stamped brass available from manufacturer or local locksmith, and supplied in the following quantities unless otherwise specified:
   a. 2 - for each keyed different lock.
   b. 3 - for each group keyed alike locks.
   c. 2 - for master keys for each system.
8. Label holders: Formed steel with satin chrome finish, 1" x 1-1/2", screw installed.
9. Shelf clips: Die formed steel, zinc plated, designed to engage in shelf adjustment holes.

2.04 TABLE FRAMES

A. Table frames: 4-1/2" high "C" channel front and back aprons, end rails and cross rails.

B. Table drawers: Provide front and back rails; drawer unit, hardware and suspension same as specified for base unit drawers.

C. Legs: 2" x 2" steel tube legs with welded leg bracket. Attach legs with two bolts to front and back aprons and weld to end rails. Each leg shall have a recessed leveling screw and a black, coved vinyl or rubber leg shoe, 2" in height.

D. Knee space frame: 2" high apron where no drawers required.

E. Leg rails and stretchers: Channel formed.

2.05 METAL FINISH

A. Metal finish:
   1. Preparation: Spray clean metal with a heated cleaner/phosphate solution, pretreat with iron phosphate spray, water rinse, and neutral final seal. Immediately dry in heated ovens, gradually cooled, prior to application of finish.
   2. Application: Electrostatically apply urethane powder coat of selected color and bake in controlled high temperature oven to assure a smooth, hard satin finish. Surfaces shall have a chemical resistant, high grade laboratory furniture quality finish of the following thickness:
      a. Exterior and interior exposed surfaces: 1.5 mil average and 1.2 mil min.

b. Backs of cabinets and other surfaces not exposed to view: 1.0 mil average.

B. Chemical Resistance
1. Test procedure: A finished test panel shall be laid flat and level on a horizontal surface. Chemical spot tests shall be made by applying 10 drops (approximately 0.5 cm^3) of each reagent identified to the surface to be tested. Each reagent spot shall be open to the atmosphere. Ambient temperature shall be 68°-72° (20-22.2°C). After a test period of one hour, chemicals shall be flushed away with cold water and the surface washed with detergent, warm water at 150°F (65.5°C) and alcohol to remove surface stains. Surface shall be examined under 100 foot candles of illumination.

2.06 EPOXY RESIN WORK SURFACE

A. Material: Chemical and abrasion resistant, durable top of one inch thick cast material of epoxy resins and inert products, cast flat, with a uniform non-glare black matte finish.

B. Backsplash curb: Same material as top, 6" high, integral with top, with 5/8" coved juncture to top surface. Provide where tops abut wall surfaces and at reagent ledges. Include end curb where top abuts end wall.

C. Reagent ledges: Same material as top. Provide 6" high x 7-1/2" wide single faced units and 6" high x 9" wide double faced units [as shown on drawings] [as required]. Ledge face shall permit installation of service fixtures and top shall be removable for access to service utilities.

2.07 SINKS, DRAINS AND TRAPS

A. Epoxy resin sinks: Integrally molded from modified thermosetting black epoxy resin, specially compounded and oven cured. Cove inside corners and pitch bottom to threaded drain outlet.
1. Size: 18" x 15" x 9" deep.
2. Drain location: Center.

B. Sink supports:
1. Cabinet sinks: Support sinks on 11 gauge, adjustable, 1" x 2" x 1" channel with reagent resistant finish. Provide two channels across width of cabinet, attached to 3/8" diameter threaded hanger rods.
2. Table sinks: Support sinks on 2" wide, U-shaped steel straps screwed to cross rails. Straps shall be 1/4" thick; 1/2" thick for sinks over 250 sq. in. in area. Straps shall have baked enamel finish.
3. Caulk joint between top and sink with non-hardening mastic.

C. Traps: 1½" size, type P in thermoplastic polyethylene.

2.08 LABORATORY FITTINGS

A. Water Service Fittings:
   1. Water service faucets and valves shall have renewable unit containing all working parts subject to wear, including replaceable stainless steel seat. Unit shall have serrations for position locking into valve body.
   2. Gooseneck vacuum breakers: Brass forgings integral with gooseneck, with renewable seat and special design valve member for fine flow control.
   3. Goosenecks shall have separate 3/8" IPS coupling securely brazed to gooseneck to provide full thread for attachment of anti-splash outlet fittings, serrated tips and filter pumps.
   4. Fixture finish: Chrome finish.

2.09 ACCESSORY EQUIPMENT

A. Pegboards:
   1. Board: Epoxy resin board finished on face and edges. Where exposed, finish back with slightly different surface texture and bevel bottom edges.

   2. Pegs: Black polypropylene pegs in 5", 6-1/2" and 8" lengths, with glassware protector base. Base of pegs shall be two prong style for mechanical attachment. Do not bond pegs to board.

B. Service Support Struts: Heavy 1/4" x 1-1/2" steel channel uprights.
   1. Fasten at top and bottom with U-shaped spreader and bolts, designed to support tops, box curbs, troughs, hoods, or other heavy loads.
   2. Service piping and drain line hanger supports are to be provided by contractor providing these services.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Casework installation:
   1. Set casework components plumb, square, and straight with no distortion and securely anchored to building structure. Shim as required using concealed shims.
   2. Bolt continuous cabinets together with joints flush, tight and uniform, and with alignment of adjacent units within 1/16" tolerance.
   3. Secure wall cabinets to solid supporting material, not to plaster, lath or gypsum board.
   4. Abut top edge surfaces in one true plane. Provide flush joints not to exceed 1/8" between top units.

B. Work surface installation:
   1. Where required due to field conditions, scribe to abutting surfaces.

2. Only factory prepared field joints, located per approved shop drawings, shall be permitted. Secure joints in field, where practicable, in the same manner as in factory, with dowels, splines, adhesive or fasteners recommended by manufacturer.
3. Secure work surfaces to casework and equipment components with material and procedures recommended by the manufacturer.

C. Sink installation: Sinks which were not factory installed shall be set in chemical resistant sealing compound and secured and supported per manufacturer's recommendations.

D. Accessory installation: Install accessories and fittings in accordance with manufacturer's recommendations. Turn screws to seat flat; do not drive.

3.02 ADJUSTING

A. Repair or remove and replace defective work, as directed by [Architect] [Owner] upon completion of installation.

B. Adjust doors, drawers, hardware, fixtures and other moving or operating parts to function smoothly.

3.03 CLEANING

A. Clean shop finished casework, touch up as required.

B. Clean countertops with diluted dishwashing liquid and water leaving tops free of all grease and streaks. Use no wax or oils.

3.04 PROTECTION OF FINISHED WORK

A. Provide all necessary protective measures to prevent exposure of casework and equipment from exposure to other construction activity.

B. Advise contractor of procedures and precautions for protection of material, installed laboratory casework and fixtures from damage by work of other trades.

+ + END OF SECTION + +

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SECTION 13220

GRANULAR ACTIVATED CARBON MEDIA

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope
   1. CONTRACTOR and GAC media supplier shall provide all labor, materials, and equipment for the installation of the GAC media into the GAC pressure vessel.
   2. CONTRACTOR and GAC pressure vessel system manufacturer shall provide all labor, materials, equipment, and start-up services for the satisfactory operation of the GAC media to be supplied to the GAC pressure vessels.
   3. CONTRACTOR shall be completely responsible for the proper start-up, operation and functions of the GAC media herein specified. CONTRACTOR shall be responsible for coordination of all interfaces with other sub-contractors, GAC pressure vessel system manufacturer, and GAC supplier to achieve the required operation.

B. Related Sections:
   1. Section 11900, GAC Pressure Vessels.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Water Works Association, (AWWA).
      a. AWWA B100, Granular Filter Material.
      b. AWWA B604, Granular Activated Carbon (GAC).

1.3 QUALITY ASSURANCE

A. GAC Media Supplier's Qualifications:
   1. CONTRACTOR shall furnish the GAC media under this Section to be the product of a firm regularly engaged in supplying this type of material.
   2. CONTRACTOR shall be prepared to document the GAC media supplier's technical competence and experience in providing the GAC media specified herein.
   3. Supplier shall have a minimum of five (5) years experience in producing materials similar to that specified herein and shall evidence of at least five (5) installations in satisfactory operation.

B. Installer's Qualifications:
   1. Provide a single installer experienced in and regularly engaged in the installation of GAC media. Submit name and qualifications to CONTRACT

CONSTRUCTION ADMINISTATOR.

C. Samplings:
   1. Sampling shall be in accordance with AWWA B604.
   2. The media manufacturer shall perform analyses to confirm gradation, effective size, uniformity coefficient, iodine number, total ash content, and specific gravity on the media prior to shipment.

D. Materials Testing:
   1. The pre-shipment media testing shall be performed by an independent test laboratory retained by the GAC supplier.
   2. Sieve analyses shall be performed in accordance with AWWA B100. Test reports shall include raw data, graphical results, computation of effective size, and uniformity coefficient.
   3. The specific gravity shall be determined for each sample. Testing shall be in accordance with AWWA B604.
   4. The GAC supplier shall provide affidavit of compliance.

E. Rejection of Filter Media:
   1. Failure of the GAC media to meet the requirements of the Contract Documents as demonstrated by the certified test reports of the testing laboratory shall constitute cause for rejection.
   2. GAC media that has been rejected shall be removed from the Site and replaced with acceptable material at CONTRACTOR'S expense.
   3. As an alternative, the CONTRACTOR may reprocess the rejected material at the Site to meet the applicable requirements.

F. Testing Laboratory:
   1. The GAC supplier shall retain the services of an independent testing laboratory, acceptable to the CONTRACT CONSTRUCTION ADMINISTATOR, to perform the tests specified herein, and to attest to the fact that the filter media will comply with the requirements set forth herein, and that all testing work has been in accordance with the methods stipulated.
   2. All costs incidental to the testing laboratory shall be borne entirely by GAC supplier.

1.4 SUBMITTALS

A. Action Submittals:
   Submit the following:
   1. Shop Drawings:
      a. CONTRACTOR shall submit GAC supplier’s product information not less than 30 days prior to shipment, including grain size ranges for the GAC media specified, specific gravity, in place density, total ash percent, molasses, and iodine number. Media sizes shall be in millimeters and include Effective Size (ES) and Uniformity Coefficient (UC). Data on flow rate

versus expansion of the media during fluidization backwashing at three different temperatures (5, 15, and 25 degrees Celsius) shall also be included. This data shall be expressed as a percentage of in-service bed depth versus backwash flow rate (gpm per square foot of contactor surface area). Clean bed headloss data at each temperature shall be included.

2. Samples:
   a. CONTRACTOR shall submit no less than 2-pound samples of GAC media following delivery of shipment, with a Certificate of Analysis which shall certify that sample shipped to the Site is from the same batch as that shipped to the Project Site, virgin GAC and in full compliance with the specifications noted herein. No GAC media shall be placed until certified copies of the testing laboratory report have been submitted to and approved by the CONTRACT CONSTRUCTION ADMINISTATOR.

B. Informational Submittals:
Submit the following:
1. Qualifications Statements:
   a. Media Supplier's qualifications.
   b. Installer's qualifications, including Manufacturer's Certificate of Proper Installation.
   c. Testing Laboratory's qualifications.
2. Source Quality Control Submittals:
   a. Submit gradation test results of GAC media, including sieve analysis prior to loading and shipment.

1.5 PRODUCT, DELIVERY, STORAGE AND HANDLING

A. Deliver GAC media to the Site to ensure uninterrupted progress of the Work.

B. Deliver GAC media in manufacturer's bulk trailers used solely for transport of GAC for potable use.

C. Conform to AWWA B604 and the requirements and recommendations of the GAC media supplier.

D. Do not order materials for shipment until ENGINEER has approved the results of the Certified Tests Results.

PART 2 - PRODUCTS

2.1 DESIGN CONDITIONS

A. Description:
1. The GAC media shall be capable of removing organic carbon, color, tastes, odors and other organic contaminants from effluent from water pretreatment processes. The

GAC shall be made from selected grades of North American based virgin bituminous coal, capable of withstanding repeated backwash procedures without significant change in physical sizes, and shall be suitable for thermal reactivation and re-use. Only bituminous coal-based re-agglomerated GAC will be acceptable.

2.2 MANUFACTURERS

A. Calgon Carbon Corporation.

B. Norit Americas, Inc.

2.3 SPECIFICATIONS

A. The GAC media shall be clean, hard, durable particles in conformance with AWWA B604, modified as follows:
   1. Deliver GAC media in bulk trailers used solely for transport of GAC for potable water use.
   2. Deliver 40,000 pounds dry GAC for each GAC pressure vessel described in Section 11900, GAC Pressure Vessel Systems.
   3. The GAC media shall be NSF Standard 61 certified virgin material manufactured from select grades of bituminous coal having the following properties:
      a. Particle Size Distribution: 12 by 40 carbon with maximum of 5 percent by weight larger than No. 12 mesh (1.68 mm) sieve and maximum of 4 percent by weight smaller than No. 40 mesh (0.42 mm) sieve.
      b. Granular activated carbon with effective size of 0.55 to 0.75 mm, Uniformity Coefficient of no greater than 1.9.
      c. Minimum abrasion number of 75 (75 percent as determined by either the stirring abrasion test or the Ro-Tap abrasion test).
      d. Minimum adsorptive capacity as measured by iodine number of 1000 mg iodine/g carbon.
      e. Maximum water soluble ash of 0.5 percent by weight.
      f. Maximum total ash content of 9 percent by weight.
      g. Maximum moisture as packed of 2.0 percent by weight.
      h. Apparent density, backwashed and drained of 0.46 to 0.65 g/cm^3.
      i. Particle density, wetted in water of 1.3 to 1.4 g/cm^3.
      j. Pore volume of 0.75 to 0.85 cm^3/g.
   4. The GAC media shall be manufactured in North America.
      a. All GAC media shall be thermally activated by re-agglomeration.
      b. All GAC media shall be virgin. GAC media shall be an agglomerated bituminous coal-based product with petroleum and coal based pitch binders sized to a granular form prior to baking and activation. Broken pellets will not be accepted. Lignite, peat, wood, coconut, direct activated, recycled, or used GAC media will not be accepted.
      c. Manufacturer shall indicate the source of the coal, GAC manufacturing location, the agglomeration/thermal process and capacity of the manufacturing facility.

d. The OWNER'S Representative reserves the right to inspect the GAC manufacturing and thermal processing facility.

PART 3 - EXECUTION

3.1 GENERAL

A. CONTRACTOR shall provide the services of a qualified technical representative of the GAC media supplier throughout the entirety of media inspection and installation to ensure proper compliance with the procedures described herein. This provision, however, shall not be construed as relieving CONTRACTOR of his overall responsibility for this portion of the Work.

B. GAC media preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing GAC, appropriate sampling and work procedures for potentially low oxygen spaces should be followed, including all applicable Federal and State requirements. Any necessary permits for work in confined space must be obtained.

3.2 PREPARATION

A. GAC pressure vessels shall be prepared as specified in Section 11900, GAC Pressure Vessels.

3.3 INSTALLATION

A. GAC media shall be installed in GAC pressure vessels by the GAC media supplier after CONTRACTOR and granular activated carbon (GAC) pressure vessel system manufacturer complete cleaning, testing, and disinfection of GAC pressure vessels and appurtenant piping to the satisfaction of ENGINEER. In no case shall GAC media be installed in the GAC pressure vessels prior to ENGINEER's acceptance of hydrostatic pressure testing results and bacteriological testing results.

B. GAC supplier shall deliver GAC media in manufacturer's bulk trailers used solely for transport of GAC for potable use. GAC will be loaded into the GAC supplier's trailers at the supplier's production or storage facility prior to shipment to the project site. Trailers shall be thoroughly cleaned prior to filling with GAC media and shall be lined or constructed with materials suitable for transporting GAC media that will be in contact with potable water. Trailer hatches shall bear dated seals affixed by supplier upon loading of GAC media into trailers, and seals shall be intact and undisturbed upon arrival at the project site. Weight tickets for all GAC media shall be provided to CONTRACT CONSTRUCTION ADMINISTATOR for the actual GAC delivered.

C. CONTRACTOR shall provide potable water supply connection for GAC transfer and

flushing/rinse water. Manufacturer shall provide all necessary hoses, site glasses, piping, and appurtenances for using this water.

D. GAC media shall be transferred into GAC pressure vessels as water slurry only, using air pressure provided via the compressed air system as the motive force. Use of a pump or eductor to transfer the GAC media from the trailer into the GAC pressure vessels will not be allowed. Bag loading or dry loading of GAC into the GAC pressure vessels is prohibited.

E. CONTRACTOR shall be responsible for cleanup of all GAC media and slurry spills that may occur during the GAC transfer operation.

F. GAC supplier shall coordinate with OWNER for training of operations **and** maintenance staff on GAC **media** filling **operation** procedures during initial installation of media.

3.4 MANUFACTURER'S SERVICES

A. A manufacturer's trained specialist, experienced in the installation of GAC media into GAC pressure vessels with at least five years of field experience, shall be provided to installation supervision, start-up and test services and operation and maintenance personnel training services. The representative will be present at the job site to complete the following services. The representative should allow a minimum of two days on site to complete the following services:
   1. Inspection of the installed equipment.
   2. Supervision of GAC loading and installation.
   3. Startup assistance.
   4. Troubleshooting.
   5. Operator training.

B. Manufacturer's representative shall operate the system in the presence of the CONTRACT CONSTRUCTION ADMINISTATOR and verify that the media conforms to requirements. Representative shall revisit the Site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

C. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 13401

INSTRUMENTATION AND CONTROL SYSTEM GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish, install, calibrate, test, start-up, and place in satisfactory operation Instrumentation and Control System (ICS) equipment necessary to perform specified functions in accordance with the requirements of the Division 13 specifications (Sections 13401 through 13701) and the Contract Drawings. CONTRACTOR shall fully coordinate the Instrumentation and Control System equipment provided under Division 13 with equipment provided under other Divisions. The system includes, but is not limited to the following major equipment:

1. Primary sensor/transducers, field instruments, and associated mounting hardware to be provided as specified in Section 13420, Primary Sensors and Field Instruments, and as shown on the Drawings.
2. A programmable controller system with processors, communications modules, and input/output modules as shown on the Drawings and as specified in Section 13451, Programmable Logic Control System Hardware and Software.
3. PLC Panels, Control Panels, and other enclosures as specified in Section 13430, Panels and Enclosures, and as shown on the Drawings. Panel mounted instruments as specified in Section 13440, Panel Instruments & Devices, and as shown on the Drawings. CONTRACTOR shall coordinate the installation, testing and start up of the various system control panels, instrumentation, and equipment provided under Division 11, Equipment, as shown on the Drawings to ensure provision of a fully coordinated and properly functioning Instrumentation and Control System.
4. Except for vendor furnished instrument cables as specified in Division 13, all interconnecting cables, wiring, conduit, and associated components required to interconnect the instruments and control panels shall be provided under Division 16, Electrical. CONTRACTOR shall test, demonstrate and verify proper functioning of all field wiring, field and panel terminations, control panels, instrument loops and equipment functions prior to start-up of the Instrumentation and Control System.
5. The Network configuration and other enclosure such as network interconnecting cables, wiring, conduit, and associated components required to interconnect network shall be provided under Section 13453, DeviceNet. CONTRACTOR shall provide the bus extender for the network if the length is longer than Manufactures' recommendation. CONTRACTOR shall test, demonstrate and verify the proper function of network.

6. Division 11, Equipment, system equipment control panels, which are to be furnished as part of a "packaged" system by the various system equipment vendors, are identified by asterisks (*) on the Instrumentation (I) drawings. Operational and functional requirements for these panels are specified in the various Division 11 Sections and are shown on the Process and Instrumentation Diagrams.

B. The Process and Instrumentation Diagrams (P&ID's) and the Specifications of this Section and the other 13400 Sections illustrate and describe the overall Instrumentation and Control System functional and operational requirements.

C. Programming of PLC and HMI will be Engineer. Loading of HMI workstation and verification of existing HMI functionality shall be by Contractor.

1.2 QUALITY ASSURANCE

A. General:
1. The instrumentation and control system as specified in Sections 13401 through 13453 shall be furnished by a single supplier who shall assume responsibility for providing a complete and integrated system.
2. All equipment, components, and materials required for the instrumentation and control system shall be furnished by a single supplier who shall assume the responsibility for adequacy and performance of all items.
3. Each supplier shall identify those system components which are not of his manufacture.
4. Each supplier shall provide his company's quality assurance plan, and for components which are not of his manufacture, the component manufacturer's quality assurance plan. The plans shall include but not necessarily be limited to: method of testing, raw material criteria, methods of documentation, station control, "Burn-In", final tests, serialization coding, and packaging.

B. Instrumentation and Control System Supplier Qualifications:
1. Shall be a financially sound firm having at least five years continuous experience in designing, implementing, supplying and supporting Instrumentation and Control Systems for municipal water treatment facilities, which are comparable to the instrumentation system in terms of hardware, software, cost, and complexity.
2. Shall have in existence at the time of bid advertisement, an experienced engineering and technical staff capable of designing, implementing, supplying, and supporting the instrumentation system and handling the submittal, testing, and training requirements.
3. Shall have a thorough working knowledge of water treatment processes and control philosophy in accordance with standard practices of the wastewater treatment industry.

4. Shall have a demonstrated record of prompt positive response to field failures.
5. Shall have a record of prompt shipments in accordance with contract obligations required for previous projects.
6. Shall have a demonstrated experience record of successful Instrumentation and Control System equipment installations.

C. Supplier's Responsibility:
   1. CONTRACTOR shall retain the system supplier to assume the responsibilities specified below. However, execution of these specified duties by the system supplier shall not relieve the CONTRACTOR of the ultimate responsibility for the control equipment.
      a. Detailed design, engineering, fabrication, assembly, wiring, testing, and debugging of the Instrumentation and Control System in accordance with the Contract Documents, the reviewed submittal drawings, and all referenced standards and codes.
      b. Preparation, assembly, submission, and correction of all Instrumentation and Control System submittals in accordance with the Contract Documents.
      c. Proper integration and interfacing of the Instrumentation and Control System hardware, field devices, and panels including required interfacing with package control systems furnished by other equipment suppliers, with existing equipment, and with the plant electrical system.
      d. Supervision of the installation of the Instrumentation and Control System, instruments, panels, consoles, cabinets, wiring, and other components required.
      e. Field modification and testing of existing control panels.
      f. Calibration, testing, and start-up of the Instrumentation and Control System.
      g. Training of OWNER personnel in operation and maintenance of the Instrumentation and Control System.
      h. Handling of all warranty obligations for the control system components.

D. Reference Standards:
   1. The following organizations have generated standards that are to be used as guides in assuring quality and reliability of components and systems; govern nomenclature; define parameters of configuration and construction, in addition to specific details in this Specification and the Contract Drawings:
      a. I.S.A., International Society of Automation.
      b. U.L., Underwriters Laboratories.
      c. A.W.W.A., American Water Works Association.
      d. N.E.M.A., National Electrical Manufacturers Association.
      e. O.S.H.A., Occupational Safety and Health Administration.
      f. A.N.S.I., American National Standards Institute.
      g. N.F.P.A., National Fire Protection Association.
      h. S.A.M.A., Scientific Apparatus Manufacturers Association.
      i. I.E.E.E., Institute of Electrical and Electronic Engineers.

j. N.E.C., National Electrical Code.
k. F.M., Factory Mutual.

1.3 COORDINATION AND REVIEW MEETINGS

A. CONTRACTOR shall be responsible for scheduling and coordinating the system installation with regard to all other work on the site and in accordance with the provisions of the General Conditions. Said coordination shall be documented on the project schedule.

B. Routine progress and coordination meetings will be scheduled by the ENGINEER. The CONTRACTOR and a representative of the system supplier shall be required to attend a minimum of five meetings with OWNER and ENGINEER at Taylor Mill Treatment Plant, 608 Grand Ave, Taylor Mill, KY 41015.

C. The purpose of the meetings shall be to review the progress of the work involving the instrumentation and control system and provide coordination for installation of the equipment to ensure construction schedules are met.

D. Representatives at the meetings shall have the competence and authority to make any and all necessary decisions. Decisions and statements made at the meetings shall commit the CONTRACTOR and system supplier to agreed procedures and schedules.

1.4 SYSTEM SUPPLIER PROJECT PERSONNEL

A. CONTRACTOR shall require the system supplier to provide a project manager with responsibilities as follows:
   1. Coordinate and schedule all work and assure that the project schedule is met.
   2. Act as the liaison with CONTRACTOR for the installation of the Instrumentation and Control System equipment and shall assist in all matters required for proper coordination and interfacing of the equipment and processes.
   3. Provide advice and technical consultation relative to installation techniques and procedures for equipment furnished.
   4. Installed system checkout, calibration, adjustment, and start-up including tuning of every control loop.
   5. Maintenance services during the field test as specified in Section 13403, Instrumentation and Control System Start-up, and Field Testing.
   6. Involvement in the on-site system training of plant personnel.
   7. Resolving of control problems encountered during initial start-up and testing of all instrumentation and control equipment.
   8. The project manager shall have a minimum of five years experience in systems engineering and start-up and shall have a thorough working knowledge of the hardware and software supplied for the instrumentation and control system.

B. CONTRACTOR shall require the system supplier to provide training personnel to comply with the requirements of Section 13404, Plant Monitoring and Control System Training.

1.5 SUBMITTALS

A. Shop Drawings:
   1. General:
      a. Make Shop Drawing submittals in accordance with the requirements of the Contract Documents, including Section 01330, Submittal Procedures. Submit all substitutions (products by manufacturers other than those specifically named) in accordance with the requirements of Section 01630, Substitution Procedures.
      b. Preparation of shop drawings shall not commence until after the pre-submittal conference specified below.
      c. Manufacture of the Instrumentation and Control System shall not commence until related submittals have been approved by Engineer.
      d. Shop Drawings shall be submitted in complete packages grouped to permit review of related items as generally outlined below.
      e. Submittals shall be made using 3-ring "D" binders with identification labels on cover and web to indicate Project, Contract, Contractor, Supplier, Submittal No., and Contents. Table of Contents and tab dividers shall be used to separate and identify information for each different submittal item.
      f. Symbol and text sizes used on all computer generated drawings and diagrams shall be of sufficient size so as to be fully legible on the actual size of plots to be provided for review and final record drawings.
      g. Review of Shop Drawings will be for conformance with Contract Documents and with regard to functions specified to be provided.
      h. All submittals shall be tailored for the project by indicating all options or accessories provided and/or deleting or crossing out non-applicable options or information.
   2. Pre-Submittal Conference:
      a. CONTRACTOR shall arrange and conduct a pre-submittal conference on the control system within 90 days of the Notice to Proceed.
      b. The pre-submittal conference shall be attended by representatives of CONTRACTOR, OWNER, the instrumentation and control system supplier, and ENGINEER at Taylor Mill Treatment Plant, 608 Grand Ave, Taylor Mill, KY 41015.. CONTRACTOR shall allot one full working day for the conference and that time shall be included in the price of this Contract.
      c. The purpose of the pre-submittal conference shall be to informally review and approve the manner in which the control system supplier intends to respond to the Contract requirements before any submittals are prepared.

d. CONTRACTOR shall prepare the items listed below for presentation at the pre-submittal conference. The information shall be submitted to the Engineer one week, at a minimum, prior to the date of the conference.
    1) A list of equipment and materials required for the control system and the brand which CONTRACTOR proposes to use for each item.
    2) A list of proposed exceptions to the plans and specifications along with a brief explanation of each. Approval shall be subject to a formal submittal.
    3) A sample of each type of submittal specified herein. These may be submittals prepared for other projects.
    4) A bar chart type schedule for all instrumentation and control system related activities from the pre-submittal conference through start-up and training. Particular emphasis shall be given to dates relative to submittals, design, fabrication, factory testing, deliveries, installation, field testing, commissioning, and training. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.
    5) A general outline of the type of tests to be performed to verify that all sensors/transducers, instruments, and control equipment are functioning properly.

3. Submittal Requirements:
    a. Product information for all sensors/transducers and field instruments. Include the following:
        1) Manufacturer's product name and model number.
        2) Instrument tag number from Contract Documents.
        3) Manufacturers standard catalog product data.
        4) Description of construction features.
        5) Performance and operation data.
        6) Installation and mounting details, instructions, and recommendations.
        7) Identification of all wiring interconnections and points of connection.
        8) Service requirements.
        9) Dimensions.
    b. Programmable Controller and Operator Interface System Information:
        1) System Description:
            a) Detailed block diagram showing system hardware configuration and identifying manufacturers and model numbers of all system components.
            b) Software language and organization.
            c) Format, protocol, and procedures for remote communications and local communications with input/output modules and peripheral devices.
            d) On-line and off-line capabilities for programming, system utilities, and diagnostics.

e) Input/output point listing with I/O module cross reference identification.
f) List of spare parts and test equipment.

2) Equipment Hardware:
a) Manufacturer's standard catalog product data for all system components.
b) Layout drawings showing front, rear, end, and plan views to scale of all processing equipment, I/O components, power supplies, and peripheral devices.
c) Construction details, features, and procedures.
d) Interconnection diagrams including termination details, cable identification lists, and cable lengths.
e) Plans showing equipment layout in control panels.
f) Installation requirements, instructions, and/or recommendations

3) Software Description:
a) Standard technical documentation covering all aspects of the programmable controller software functions and capabilities, including instruction set description and programming procedures related to control, monitoring, logging, and alarming functions.
b) Documentation describing memory type, size and structure and listing I/O and Data Table memory and size of memory available for programs.

c. Panels, Consoles, and Cabinets Information:
1) Layout Drawings include the following:
a) Front, rear, and interior subpanel views to scale. Scale shall be identified on the Drawings.
b) Dimensional information.
c) Tag number and functional name of components mounted in and on panel or enclosure.
d) Product information on all panel components. Include information as specified above for the field sensors/transducers and instruments.
e) Nameplate location and legend including text, letter size, and colors to be used.
f) Location of anchoring connections and holes.
g) Location of external wiring and/or piping connections.
h) Mounting and installation details.
i) Subpanel layouts and mounting details for all items located inside control panels.

2) Panel schematic and internal point-to-point wiring and/or piping diagrams, include the following:
a) Name of panel or enclosure.
b) Wiring sizes, types, and numbers.
c) Piping sizes and types.
d) Terminal strip and post numbers for all interconnections.

e) Color coding.
f) Functional name and manufacturer's designation for components to which wiring and piping are connected.

3) Electrical control schematics in ladder format, utilizing graphic symbols in accordance with IEEE standards, for all circuits indicated in the Specifications or on the Contract Drawings. No "typical" wiring diagrams will be acceptable and no tables or charts to describe wire numbers will be acceptable. All wires shall be labeled and shown on the submittal drawings.
4) Plan showing equipment layout in each area.
5) Stock lists or Bill of Materials for each panel including tag number, functional name, manufacturer's name, manufacturer's model number, and quantity for all components mounted in or on the panel or enclosure.
6) Detailed heat calculations for each panel or enclosure to verify that there is sufficient dissipation and/or generation of heat to maintain interior panel temperatures within the maximum and minimum operating temperature of all panel components with the ambient temperatures as specified.
7) Over-current coordination study, including fuse and circuit breaker time-current curve overlays, to confirm proper coordination between all over-current devices, internal and external to panels.

d. Field wiring and piping diagrams, include the following:
1) Wiring and piping sizes, types, and numbers.
2) Terminal strip numbers for each wire termination.
3) Color coding.
4) Conduits, junction boxes, and pull boxes in which wiring is to be located.
5) Location, functional name, and manufacturer's designation of items to which wiring and/or piping are connected.
6) Point-to-point wiring diagrams shall include all interconnections between field devices, panels, control stations, lighting panels, and motor starters.

e. Instrument loop diagrams for all analog display and control loops prepared using ISA standard symbols in accordance with ISA standard S5.4, include the following:
1) Functional name of loop.
2) ISA tag numbers as shown in the Specifications and on the Contract Drawings.
3) Functional name and manufacturer’s name and model, product or catalog number for each item in the loop.
4) Location of each item.
5) Signal type and calibrated range, scale, or setpoint for each item.
6) Transmitter output drive and receiver input impedances. Show total loop impedance and reserve.
7) Identification of loop and instrument energy sources.

8) Identification of all interconnections. Include wire numbers, sizes and types, cable numbers, conduit numbers, intermediate junction box identification and location, terminal numbers, and grounding connections.

f. Factory Test and Plant Monitoring schedules/procedures shall be as specified in Sections 13402, Plant Monitoring and Control System Factory Testing, and 13403, Plant Monitoring and Control System Start-up, and Field Testing.

g. Prove existing "as-built" drawings for all communications networks before installation of any new equipment. Drawings shall indicate make and model of all equipment, addresses, and locations, media type, converters, panels, etc.

B. Control System Operation and Maintenance Manuals:

1. Furnish six copies of O&M manuals for the Instrumentation and Control System in accordance with the requirements of Section 01781, Operation and Maintenance Data, and the supplemental requirements below:

2. The O&M manuals shall include the following:

a. Name, address, and telephone number of each manufacturer's local service representative.

b. Complete list of supplied system hardware parts with full model numbers referred to system part designations, including spare parts and test equipment provided.

c. Copy of all approved submittal information and system shop drawings as specified herein with corrections made to reflect all shop drawing review comments and the actual system as tested and delivered to the site for installation. Half-size black line reproductions shall be provided for all shop drawings larger than 11 by 17 inches.

d. Complete up-to-date system software documentation as described above. The software documentation shall be in suitable binders and shall be labeled with the system supplier's name, the date, and the project name

e. Manufacturer's Original Copies of Hardware, Installation, Assembly, Programming, and Operations Manuals for all control system components. Manuals shall include the following information:

1) General descriptive information covering the basic features of the equipment.

2) Physical description covering layout and installation requirements and all environmental constraints.

3) Standard technical documentation covering the procedures for programming, operation, start-up, shutdown, and calibration of the equipment and explaining how the various control functions are performed.

4) Principles of operation explaining the logic of operation; provide information covering operation to a component level.

5) Maintenance procedures covering checkout, troubleshooting, and servicing; checkout procedures shall provide the means to verify the satisfactory operation of equipment, troubleshooting

procedures shall serve as a guide in determining faulty components, and servicing procedures shall cover requirements and recommended time schedule for calibration, cleaning, lubrication and other housekeeping and preventive maintenance procedures.

6) Wiring, schematic, and logic diagrams.
7) Safety considerations relating to operation and maintenance procedures.
8) Manufacturer's recommended spare parts list with model numbers.

3. All O&M Manuals shall be tailored for the project by indicating all options or accessories provided and/or deleting or crossing out non-applicable options or information. Submittals not complying with this will be returned without review and shall be resubmitted when in compliance.
4. The O&M Manuals shall be printed on heavy, first quality paper. Large manuals shall be submitted in three ring binders with a table of contents and index tabs to identify the various devices. The table of contents shall reference the applicable specification section(s) for each item and shall be included in each volume of multi-volume manuals. Comply with the requirements of Section 01781, Operations and Maintenance Data.

C. Record Drawings and Documentation:
1. CONTRACTOR and system supplier shall revise all system shop drawings and submittals to reflect as-built conditions in accordance with the requirements of the Contract Documents and the supplemental requirements below.
2. Six copies of all revised shop drawings and documentation shall be submitted to the Engineer to replace out-dated drawings and documentation contained in the System O&M Manuals. Half-size black line sets shall be provided for all drawings larger than 11 by 17. Specific instructions for out-dated drawing removal and replacement shall be provided with the record drawing submittal.
3. Full-size black line prints of wiring diagrams applicable to each control panel shall be placed inside a clear plastic envelope and stored in a suitable print pocket or container inside each control panel.

D. Reports:
1. Two copies of the following reports shall be submitted to the ENGINEER:
a. Factory Test Reports as specified in Section 13402, Plant Monitoring and Control System Factory Testing.
b. Installation Inspection and Field Calibration Reports as specified in Section 13403, Plant Monitoring and Control System Start-up, and Field Testing.

1.6 EQUIPMENT DELIVERY, HANDLING AND STORAGE

A. CONTRACTOR shall make all arrangements for transportation, delivery and storage of the equipment and materials in accordance with the requirements of the

Contract Documents, requirements of the system supplier, and requirements of the equipment manufacturers.

B. Instrumentation and Control System equipment shall be packaged at the factory prior to shipment to protect each item from damage during shipment and storage. Containers shall be protected against impact, abrasion, corrosion, discoloration and/or other damages. Clearly label contents of each container and provide information on the required storage conditions necessary for the equipment. Keep OWNER and ENGINEER informed of equipment delivery.

C. All equipment shall be handled and stored in accordance with manufacturer's instructions and relevant organization standards. Equipment shall be protected from weather, moisture and other conditions which could cause damage. Items which require a controlled environment for storage such as panels and microprocessor units shall be stored in a climate controlled warehouse or facility. System supplier shall notify CONTRACTOR in writing, with copies to OWNER and ENGINEER, of the storage requirements and recommendations for the equipment prior to shipment.

1.7 GENERAL DESIGN REQUIREMENTS

A. Power Supplies:
   1. All electrically powered equipment and devices shall be suitable for operation on 120 volt ± 10 percent, 60 Hz ± 2 Hz power. If a different voltage or closer regulation is required, a suitable regulator or transformer shall be provided.
   2. Appropriate power supplies shall be furnished by CONTRACTOR for all two-wire transmitters. Power supplies shall be mounted in control panels or enclosures.
   3. Design all power supplies for a minimum of 130 percent of the maximum simultaneous current draw.
   4. A power on-off switch or circuit breaker shall be furnished for each item requiring electrical power.
   5. Provide isolation transformers and/or line voltage regulators as required to eliminate electrical noise and/or transients entering on the primary power line. Coordinate and comply with requirements shown on the Electrical Drawings and specified elsewhere in Division 16.

B. Signal Requirements:
   1. The control system shall be designed to use 4 to 20 mA dc analog signals, unless otherwise specified.
   2. Signal converters and repeaters shall be provided where required. Power supplies shall be sized adequately for signal converter and repeater loads.
   3. Signals shall be isolated from ground.
   4. Signals shall not have a transient dc voltage exceeding 300 volts over one millisecond nor a dc component over 300 volts.

5. The system will be used in a municipal treatment plant environment where there can be high energy ac fields, dc control pulses, and varying ground potentials between the sensors/transducers and the system components. The system design shall be adequate to provide proper protection against interferences from all such possible situations.

C. Miscellaneous:
   1. All Instrumentation and Control System components shall be heavy-duty types, designed for continuous service in a municipal treatment plant environment. The system is to contain products of a single manufacturer, when possible, and to consist of equipment models which are currently in production.
   2. All Instrumentation and Control System components shall be designed to automatically return to accurate measurement within 15 seconds upon restoration of power after a power failure or when transferred to standby power supply.
   3. Surge protection shall be provided for all power supplies, field instruments, and all other control system components to protect against damage by electrical surges.
   4. All field-mounted instruments and system components shall be designed for installation in humid and slightly corrosive service conditions. All field mounted instrument enclosures, junction boxes, and appurtenances shall conform to NEMA 4X requirements unless otherwise specified.
   5. All relays with interconnections to field devices shall be wired through terminal blocks. Terminals as part of the relay base are not an acceptable alternate.
   6. All panel mounted instruments, switches, and other devices shall be selected and arranged to present a pleasing coordinated appearance. All front of panel mounted devices shall be of the same manufacturer and model line.
   7. All components furnished including field and front and rear of panel instruments shall be tagged with the item number and nomenclature indicated on the Contract Documents and/or approved Shop Drawings.
   8. Ranges and scales specified herein shall be coordinated to suit equipment actually furnished.
   9. Field-mounted devices shall be treated with an anti-fungus spray.
   10. Field-mounted devices, instruments and control panels/enclosures shall be protected from exposure to freezing temperatures and from overheating due to prolonged exposure to high ambient temperatures, and shall be provided with sunshields to protect the enclosure surfaces from the additional heating effects of exposure to direct sunlight.

D. Environmental Conditions:
   1. The control system shall be designed and constructed for continuous operation under the following temperature and humidity conditions:
      a. Indoor locations for control panels and instruments:
         1) Ambient Temperature: shall be as shown on the HVAC drawings.
         2) Relative Humidity: 98 percent maximum.

b. Outdoor locations for control panels and instruments:
   1) Ambient Temperature: -25 to 110 degrees F.
   2) Relative Humidity: 100 percent maximum.

E. System Designs:
   1. Range, scale, and setpoint values specified or shown are for initial setting and configuration. Coordinate these values with the actual equipment furnished to implement proper and stable process action as systems are placed in operation.
   2. For any items where ranges, scales, and setpoints may not have been specified, CONTRACTOR shall submit a recommendation to the ENGINEER for review.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

+ + END OF SECTION + +

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SECTION 13402

INSTRUMENTATION AND CONTROL SYSTEM FACTORY TESTING

PART 1 - GENERAL

1.1 REQUIREMENTS AND RESPONSIBILITIES

A. CONTRACTOR shall provide all labor, material, equipment and incidentals as shown, specified and required to perform factory testing, before shipment, at the manufacturer's facility to verify that system components are functioning properly and that they meet the functional and performance requirements of the Contract Documents.

B. CONTRACTOR shall submit information on factory testing procedures to verify that testing shall fulfill the requirements as specified herein. Submittal shall be made at least two months in advance of any scheduled testing and shall include dates of scheduled tests.

C. CONTRACTOR shall notify ENGINEER in writing at least four weeks before expected initiation of tests. Owner and Engineer reserve the right to witness test panels and enclosures. If test site is less than 200 miles from job site, cost of lodging, meals, and travel for OWNER and ENGINEER will be their respective responsibilities, otherwise expenses are Contractor’s responsibility. Regardless of distance, if factory tests are not performed on the agreed date as a result of CONTRACTOR’s or manufacturer's action, aforementioned costs shall be borne by CONTRACTOR. The presence of OWNER and ENGINEER during testing does not relieve the CONTRACTOR from conforming to the requirements of the Contract Documents and shall in no way imply acceptance of the equipment.

D. The Factory Test cannot begin until all related Instrumentation and Control System shop drawings have been submitted and approved.

1.2 SYSTEM HARDWARE INSPECTION AND TESTING

A. All system hardware components shall be tested to verify proper operation of the equipment as stand alone units. Test shall include, but not be limited to, the following:

1. AC/DC power checks.
2. Power fail/restart tests.
3. Diagnostics checks.
4. Test demonstrating that all specified equipment functional capabilities are working properly.

B. All panels's, console and cabinets wiring shall be checked to verify compliance with Specifications and approved shop drawings. Inspection shall include, but not be limited to, the following:
   1. Nameplates and tags.
   2. Wire sizes and color-coding.
   3. Terminal blocks spare requirements.
   4. Proper wiring practices and grounding.
   5. Enclosure flatness, finish, and color.
   6. Annunciator and terminal block spares.

C. Three sets of current, as-built drawings, for all panels and enclosures to be tested, shall be provided at the Factory Test for use by OWNER and ENGINEER.

D. All PLC programming required to perform I/O testing, as specified below, shall be provided by Contractor. Three sets of current PLC programs shall be available to OWNER during the witnessed factory test.

E. All PLC input/output devices shall be tested to verify proper operation and basic calibration. CONTRACTOR shall test all input and output points prior to the witnessed factory test and shall provide copies of signed and certified check lists or other documentation to demonstrate the completion of I/O testing. All I/O (both digital and analog), shall be tested during the witnessed factory test. PLC I/O testing shall include, as a minimum, the following:
   1. Simulate a field digital input for each PLC digital input point at the terminal strip of the control panel and verify the signal presence at the PLC Data Table.
   2. Simulate a field analog input for each PLC analog input point at the terminal strip of the control panel and verify the signal presence at the PLC Data Table.
   3. Force an output for each PLC digital output point and verify the signal presence at the terminal strip in the control panel.
   4. Simulate an analog output for each PLC analog output point and verify signal presence at the terminal strip in the control panel.

F. PLC communications shall be tested to verify that communications between units is operating properly. Communications shall be tested by simulating an input at the remote rack and verifying PLC processor response.

1.3 FACTORY TEST REPORTS

A. Panel and control component modifications and corrections required as a result of testing shall be completed and documented before shipment of the panels. Panels shall not be shipped from the factory until two copies of certified factory test reports indicating satisfactory performance have been submitted and approved. Factory test reports shall include the following information:
   1. List of tests performed.
   2. Certified check lists or documentation verifying all I/O has been tested, as specified above.

3. Documentation verifying all panel wiring has been checked.
4. List of required modifications or corrections identified during the Factory Test and corrective action taken.
5. Factory test reports shall be signed and dated by an authorized representative of the system supplier.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

+ + END OF SECTION + +

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SECTION 13403

INSTRUMENTATION AND CONTROL SYSTEM START-UP, COMMISSIONING, AND FIELD TESTING

PART 1 - GENERAL

1.1 SYSTEM CHECK-OUT AND START-UP RESPONSIBILITIES

A. CONTRACTOR shall provide all labor, materials, equipment, and incidentals necessary to perform and coordinate the check-out, start-up, commissioning, and field-testing of the Instrumentation and Control System.

B. CONTRACTOR shall retain the services of the system supplier to supervise and/or perform check-out and start-up of all system components. As part of these services, the system supplier shall include, for those systems which they did not manufacture, the services of authorized manufacturer's representatives to check the equipment installation and place the equipment in operation. The manufacturer's representative shall be thoroughly knowledgeable about the installation, operation, and maintenance of the equipment.

1.2 SYSTEM CHECKOUT AND START-UP

A. CONTRACTOR, system supplier, and instrument suppliers as applicable, shall perform the following:
   1. Check and approve the installation of all instrumentation and control components and all cable and wiring connections between the various system components prior to placing the various processes and equipment into operation.
   2. Conduct a complete system checkout and adjustment, including calibration of all instruments, tuning of control loops, checking operation functions, and testing of final control actions. All problems encountered shall be promptly corrected to prevent any delays in start-up of the various unit processes.
   3. PLC and Ethernet communications shall be tested to verify that communications between components is operating correctly.

B. CONTRACTOR shall provide all test equipment necessary to perform the testing during system checkout and start-up.

C. CONTRACTOR and system supplier shall be responsible for initial operation of the Instrumentation and Control System and shall make any required changes, adjustment or replacements for operation, monitoring, and control of the various processes and equipment necessary to perform the functions intended.

D. CONTRACTOR shall furnish to the ENGINEER certified calibration reports for field instruments and devices, specified in Section 13420, Primary Sensors and Field

Instruments, and panel mounted devices, specified in Section 13440, Panel Instruments and Devices, as soon as calibration is completed.

1. Receipt of any calibration certificate shall in no way imply acceptance of any work or instrument.
2. The calibration certificate forms shall be prepared and furnished by CONTRACTOR and shall contain the information shown on the sample calibration certificate included at the end of this section. All calibration data pertinent to the individual instruments shall be provided on the calibration certificates.
3. Each calibration certificate shall be signed and dated by an authorized representative of CONTRACTOR. Three copies of each completed certificate shall be submitted to ENGINEER.

E. CONTRACTOR shall furnish to ENGINEER three copies of an installation inspection report certifying that all equipment has been installed correctly and is operating properly. The report shall be signed by authorized representatives of both CONTRACTOR and the system supplier.

1.3 COMMISSIONING

A. Following the Instrumentation and Control System checkout and initial operation, CONTRACTOR shall perform a complete system test in the presence of the ENGINEER to verify that all equipment is operating properly as a fully integrated system, and that the intended monitoring and control functions are fully implemented and operational.

1. Commissioning can only begin when all instruments and control panels are installed and wired. Operation and Maintenance manuals as specified in Section 13401, Plant Monitoring and Control System General Requirements, and a schedule for training must be approved prior to Commissioning.
2. All spare parts must be on site and accepted prior to Commissioning.
3. CONTRACTOR shall submit to the ENGINEER a schedule for Commissioning, including a proposed start date, at least three weeks in advance.

B. Commissioning shall include, as a minimum, the following checks:

1. All wiring shall be checked at each termination point for correct wire size, type, color, termination and wire number.
2. All instruments and devices shall be checked to verify compliance with the specifications and approved shop drawings. The calibration of analog devices shall be verified including the zero and span.
3. Analog wiring shall be checked for correct polarity and ground continuity at each termination point in the loop.
4. All analog loops shall be verified at each termination point at 0%, 50%, and 100% signal levels.

C. All PLC hardware shall be thoroughly tested to verify proper operation. System testing shall include, as a minimum, the following:

1. All digital inputs shall be activated at the field element to verify proper response at the digital input card.
2. All analog inputs shall be tested at the field transmitter over a full range to verify proper response at the analog input card.
3. All digital and analog outputs shall be forced to verify proper response at the final control element.
4. Communications shall be tested between all components.

D. CONTRACTOR shall provide the following documentation for use during the Commissioning effort. This documentation is in addition to that included in Section 13401.
1. Complete panel schematic and internal point-to-point wiring interconnect drawings as detailed in Section 13401, Plant Monitoring and Control System General Requirements.
2. Complete electrical control schematics in accordance with IEEE standards.
3. Complete panel layout drawings as detailed in Section 13401, Plant Monitoring and Control System General Requirements.
4. Complete field wiring diagrams as detailed in Section 13401, Plant Monitoring and Control System General Requirements.
5. Complete instrument loop diagrams as detailed in Section 13401, Plant Monitoring and Control System General Requirements.
6. Completed Calibration Certificates for all field and panel devices that require adjustment or calibration.
7. CONTRACTOR shall provide one set of Commissioning documentation for the OWNER'S personnel, one set for field use, and the required number of sets for CONTRACTOR’S use.
8. The drawings corrected and modified during Commissioning shall form the basis for the "As-Built" record drawing requirement as specified in Section 13401, Plant Monitoring and Control System General Requirements.

E. Any defects or problems found during the Commissioning effort shall be corrected by CONTRACTOR and then retested to demonstrate proper operation.

1.4 FIELD TEST

A. Following the completion of Commissioning, the instrumentation and control system including field sensors/transducers, panels, and instruments shall be running and fully operational for a continuous 60 day Field Test. The Field Test may occur at different times in the construction schedule for the various process areas, as the areas are completed. The Field Test cannot begin until all defects identified during Commissioning have been corrected and the OWNER and ENGINEER agree that the Field Test can begin.

B. During the Field Test, the programmable controller and HMI software shall be loaded and tested by the Engineer, and the control system shall be available to plant operating personnel for use in the normal operation of the plant.

C. The conditions listed below shall constitute system failures which are considered critical to the operability and maintainability of the system. The Field Test shall be terminated if one or more of these conditions occur. Following correction of the problem, a new 60 consecutive day Field Test shall begin.
   1. Failure to repair a problem within 120 consecutive hours from the time of notification of a failure.
   2. Recurrent type hardware problems, if the same type of problem occurs three times or more.

D. The following conditions shall constitute a system failure in determining the 60 consecutive day Field Test.
   1. Loss of communications between devices on the communications network(s).
   2. Failure of one or more input/output components.
   3. Failures affecting ten or more input/output points simultaneously.
   4. Failures of any type affecting one more regulatory control loops or sequential control strategies thereby causing a loss of the automatic control of the process variable or process sequence operation.
   5. Failure of a power supply.
   6. Failure of three or more primary sensors/transducers or field instruments simultaneously.

E. Completion of the 60 consecutive day Field Test without any restarts, will constitute acceptance of the instrumentation and control system by the OWNER.

F. All parts and maintenance materials required to repair the system prior to completion of the Field Test shall be supplied by CONTRACTOR at no additional cost to the OWNER. If parts are obtained from the required plant spare parts inventory, they shall be replaced to provide a full complement of parts as specified.

G. An instrumentation and control system Malfunction/Repair Reporting Form shall be completed by the plant personnel and/or ENGINEER to document failures, to record CONTRACTOR notification, arrival and repair times and CONTRACTOR repair actions. Format of the form shall be developed and agreed upon prior to the start of the Field Test.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

CALIBRATION CERTIFICATE

Tag Number/Loop Number:_____
Loop Description:_____
Instrument Location:_____
Manufacturer:_____
Model Number_____
Adjustable Range:_____
Calibrated Range:_____
Remarks:_____
_____

Installation Per Manufacturer's Requirements? Yes No
Installation Per Contract Documents? Yes No
If "No", explain:

_____
_____

Calibration Test:

Input (Units)	Output (Units)	Accuracy	
0%	_____	_____	_____
10%	_____	_____	_____
25%	_____	_____	_____
50%	_____	_____	_____
75%	_____	_____	_____
90%	_____	_____	_____
100%	_____	_____	_____

Switch Test:

	Setting	Deadband	Switch Point Upscale	Switch Point Downscale
Setpoint 1	_____	_____	_____	_____
Setpoint 2	_____	_____	_____	_____
Setpoint 3	_____	_____	_____	_____
Setpoint 4	_____	_____	_____	_____

I hereby certify that the above information is correct and accurate, to the best of my knowledge, and that the instrument indicated above has been supplied, installed, calibrated, and testing in accordance with the manufacturer's recommendations and the Contract Documents, unless otherwise noted.

Receipt of this Calibration Certification shall in no way imply acceptance of any work or instrument supplied as a part of this Contract.
Contractor's Signature: _____ Date: _____

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SECTION 13404

INSTRUMENTATION AND CONTROL SYSTEM TRAINING

PART 1 - GENERAL

1.1 REQUIREMENTS AND RESPONSIBILITIES

A. CONTRACTOR shall provide all labor, materials, equipment and incidental as shown, specified and required to perform and coordinate all required training at times and locations acceptable to the OWNER.

B. CONTRACTOR shall retain the services of the system supplier to provide operation and maintenance training for all Instrumentation and Control System equipment as specified herein.

C. For equipment items not manufactured by the system supplier, system supplier shall provide for on-site training by an authorized representative of the equipment manufacturer. The manufacturer's representative shall be fully knowledgeable in the operation and maintenance of the equipment.

D. CONTRACTOR shall be responsible for all costs associated with training and shall provide all required materials, texts, and supplies.

E. All training shall be conducted in normal eight-hour working days until conclusion of the training course.

F. All training sessions may be video taped by OWNER at OWNER’S expense.

G. Comply with the requirements of Section 01821, Instruction of Operations and Maintenance Personnel.

H. Contractor shall provide separate training sessions for operator and maintenance personnel.

1.2 SUBMITTALS

A. Within 120 days of the effective date of the Notice to Proceed, CONTRACTOR shall submit his plan for training. Included in the plan shall be course outlines and schedules.

B. Training Submittal Requirements:
   1. CONTRACTOR shall submit the following information for each training course as described below, a minimum of two months in advance of any scheduled training.

a. A detailed outline of the topics to be covered including expected duration of each topic.
b. The name(s) and qualifications of the person(s) proposed to conduct the training.
c. A list of all operations manuals, maintenance manuals, supplies, etc. to be provided to the training course attendees.

1.3 ON-SITE TRAINING

A. Primary Sensors/Transducers and Field Instruments:
1. Provide on-site operation and maintenance training sessions by the system supplier and the equipment manufacturer representatives prior to placing the equipment in continuous operation. The qualified equipment manufacturer's representatives shall provide, as a minimum, the following operation and maintenance training:
a. Pressure Gauge/Switches, Diaphragm Seals, Inline Pressure Element: One hour of training.
b. Venturi Flowmeter: One hour of training.
c. Radar Level Transmitter: One hour of training.
d. Differential Pressure Transmitter: One hour of training.
e. Float Level Switch: One half hour of training.
f. Turbidity Analyzers: Two hours of training.
g. pH Analyzer: One hour of training.
h. TOC Analyzer: Two hour of training.
2. Operator and maintenance training shall accomplish the following:
a. Provide instruction covering use and operation of the equipment to perform the intended functions.
b. Provide instruction covering procedures for routine, preventative, and troubleshooting maintenance including equipment calibration.
c. Explain procedures for placing the equipment in and out of operation and explain necessary actions and precautions to be taken regarding the overall instrumentation and control system.

B. Control Panels:
1. Within first thirty days of continuous operation of the control panels, retain qualified representatives of the system supplier and equipment manufacturer to instruct on-site OWNER personnel. The qualified representatives of the system supplier and equipment manufacturer shall provide, as a minimum, the following control panel training:
a. All PLC Panels: Two hours of training.
2. Operator and maintenance training shall accomplish the following:
a. Provide instruction covering the use and operation of the control panels and all items contained on or within the control panels.
b. Provide instruction covering procedures for routine, preventative, and troubleshooting maintenance including device calibration.

c. Explain, with assistance from OWNER'S authorized (programming) agent, procedures for placing the control panels in and out of operation.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

+ + END OF SECTION + +

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SECTION 13420

PRIMARY SENSORS AND FIELD INSTRUMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall furnish, install, calibrate, test, adjust, and place into satisfactory operation the primary sensors and field instruments as shown on the Drawings and specified herein.
   2. The Drawings and Specifications illustrate and specify functional and general construction requirements of the sensors and field instruments and do not necessarily show or specify all components, wiring, piping, and accessories required to make a completely integrated system. CONTRACTOR shall provide all components, piping, wiring, accessories, and labor required for a complete workable and integrated system.
   3. CONTRACTOR shall be responsible for installing in-line flow elements and for providing taps in the process piping systems for installation of other flow and pressure sensing instrumentation.

B. Coordination: Coordinate with other suppliers for installation of all items specified herein and required to ensure the complete and proper interfacing of all the components and systems.

1.2 QUALITY ASSURANCE

A. Comply with the requirements of Section 13401, Instrumentation and Control System General Requirements.

B. Acceptable Manufacturers:
   1. Furnish primary sensors and field instruments by the named manufacturers or equal equipment by other manufacturers.
   2. The named manufacturers have been specified to establish the standard of quality and performance of the equipment to be supplied.
   3. Obtain all sensors and field instruments of a given type from the same manufacturer.

C. Manufacturers' Responsibilities and Services:
   1. Design and manufacture the primary sensors and field instruments in accordance with the applicable general design requirements specified in Section 13401, Instrumentation and Control System General Requirements. and the detailed specifications herein.

2. Field supervision, inspection, start-up, and training in accordance with the requirements of Section 13403, Instrumentation and Control System Start-up, Commissioning and Field Testing, and Section 13404, Instrumentation and Control System Training.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements specified in Section 13401, Instrumentation and Control System General Requirements.

B. The primary sensors and field instruments shall not be delivered to the site until all product information and system shop drawings for the sensors and instruments have been approved.

1.4 SUBMITTALS

A. Comply with the requirements specified in Section 13401, Instrumentation and Control System General Requirements.

1.5 MATERIALS OF CONSTRUCTION FOR WETTABLE PARTS

A. Provide compatible materials of construction for primary sensors and field instrument (wetted) parts that come in contact with the process fluids listed in the Instrument Index.

1.6 INSTRUMENT INDEX

PART 2 - PRODUCTS

2.0 GENERAL

2.0.1 IDENTIFICATION TAGS

A. Type: White engraved phenolic.

B. Function: Identify specific characteristics of all sensors and field instruments. All instruments, whether field or panel mounted, shall have an identification tag.

C. Performance Requirements:
   1. Tag numbers of sensors and field instruments shall be as shown on the drawings and as specified. For items not shown or specifically tagged, the item tag number shall be established by the system supplier.
   2. Information to be permanently engraved onto the tag shall include the identifying tag number, manufacturer, model number, service, and range.
   3. The tags shall be fastened to the device with self-tapping stainless steel screws. Where fastening with screws cannot be accomplished the tags shall be permanently attached to the device by a circlet of stranded stainless steel wire rope and clamp.
   4. All sensors and field instruments mounted on or within control panels and enclosures shall have the identification tag installed so that the engravings are easily visible to service personnel. Panel mounted devices shall have the tag attached to the rear of the device.

D. Construction Features:
   1. Tags shall be engraved with 3/16-inch letters and constructed as follows.
      a. 3/32-inch thick laminated phenolic for engraving composed of core, laminated on both sides with a matte (non-glare) finish cover sheet.
      b. Core to be black; cover sheet to be white.
      c. Mounting holes to be centered on width and 1/4 inch from each end.

2.0.2 PROCESS TAPS, SENSING LINES AND ACCESSORIES

A. Water Pressure Sensing Lines and Accessories for Flow and Pressure Transmitters:
   1. Material: Copper Water Tube, ASTM B-88, Type L, drawn temper or annealed.
   2. Pressure Rating: 150 psi.
   3. Size: 1/2 inch O.D. for water.
   4. Connections: Brass Compression Type, "Swagelok" by Crawford, or equal.
   5. Shut-off Valves:
      a. Type: Ball.
      b. Pressure Rating: 150 psi.
      c. Body, Ball and Stem: Brass.
      d. Packing: High Density TFE.
      e. Handle: Nylon with metal travel stops.
      f. Support Rings: TFE coated brass.
      g. End Connections: Removable "Swageloks", or equal.
      h. Model: Whitey 45 series for water, or equal.
   6. Manifolds:

a. Type: 5-valve and 3-valve meter manifolds for differential pressure transmitters and pressure transmitters, respectively.
b. Materials: Type 316 stainless steel Body, Bonnets and Stems; Delrin seats; Teflon Packing.
c. Manufacturer: Anderson-Greenwood; or equal.

B. Pressure Tap Sensing Lines and Accessories for Pressure Gauges and Pressure Switches:
1. For Process Sensing Taps in Ductile Iron, Steel and Stainless Steel Piping Systems:
a. Material and Fittings: Type 304 Stainless Steel Pipe (ASTM A 312) and threaded fittings and adapters (ASTM A 403).
b. Sizes: 1/2 inch minimum for main sensing piping and 1/4 inch gauge and switch connections.
c. Pressure Rating: Equal to or greater than the applicable system test pressure as specified in the Schedule in Section 15052, Exposed Piping Installation.
d. Accessories:
1) For applications not requiring diaphragm seals, provide separate 1/2 inch Type 316 stainless steel threaded ball valve for each gauge and switch.
2) For applications requiring diaphragm seals, provide a separate 1/2 inch threaded Type 316 stainless steel ball valve for seal process side shutoff. Ball valves shall be provided in accordance with specifications in Section 15100, Valves and Appurtenances.
2. For Process Sensing Taps in Copper and Thermoplastic Piping Systems:
a. Pipe Material and Fittings: Use same type of pipe material and fittings as that used in the process piping system. PVC pipe and fittings shall be provided in accordance with the requirements of Section 15067, Thermoplastic Pipe.
b. Sizes: 1/2 inch minimum for main process sensing piping and 1/4 inch for gauge and switch connections.
c. Pressure Rating: Equal to or greater than the applicable system test pressure as specified in Section 15052, Exposed Piping Installation.
d. Accessories:
1) For copper piping system taps with or without seals, provide a separate 1/2 inch minimum threaded brass or bronze ball valve for each gauge and switch.
2) For PVC piping systems with or without diaphragm seals, provide a separate 1/2 inch threaded ball valve for process sensing line shutoff. Ball valves shall be provided in accordance with the specifications in Section 15100, Valves and Appurtenances.

C. Pressure Tap Sensing Lines and Accessories for Differential Pressure Gauges:
1. Process tubing and isolation valves: provide process tubing and isolation valves as shown on the Drawings and in accordance with the following requirements:
a. Process Tubing:
1) Material: Type 316 stainless steel tubing, ASTM A269.
2) Size: 3/8-inch outside diameter, medium wall thickness.
3) Connections: Type 316 stainless steel compression type, “Swagelok Tube Fittings” by Swagelok Co., or Equal

b. Isolation Valves:
   1) Type: Ball. Ball valves shall be provided in accordance with the specifications in Section 15100, Valves and Appurtenances.

2.0.3 AC POWER ON-OFF SWITCH

A. Function: Local power on-off selector switch for instruments. All four-wire transmitters, as identified in the individual instrument sub-sections below and as shown on the Drawings, shall be provided with a 120 VAC power on-off selector switch located at the instrument.

B. Construction Features:
   1. Selector Switch: NEMA 4X rated, SPDT. Comply with the requirements of Specification Section 13440, Panel Mounted Instruments.
   2. Enclosure: NEMA 4X rated, non-metallic, Allen Bradley 800H rosite glass polyester enclosure, or equal.

2.1 LEVEL INSTRUMENTATION

2.1.1 LEVEL TRANSMITTERS - RADAR TYPE

A. Type: Microprocessor based, non-contacting, 25GHz pulsed radar type continuous liquid level measuring system consisting of a 4" horn antenna with a 4" 150lb. flange and integral transmitter. The radar liquid level measuring system shall produce an output signal linear with level.

B. Performance Requirements:
   1. Range: As specified in the Instrument Schedule.
   2. Local Indication: Identical to range. Digital display showing Engineering units, as well as bar graph to display 0 to 100 percent of calibrated span.
   3. Accuracy: 0.1 percent of range.
   4. Reaction Time: 1 second, minimum.
   5. Vibration Resistance: 20 to 2000 Hz.
   6. Power: 24 VDC loop power.
   7. Output: Isolated 4-20 mA DC, into 0 to 550 ohms.
   8. Ambient Temperature Limits:
      a. Transmitter: -40 to 176 degrees F.
      b. Antenna/seal: -40 to 176 degrees F
   9. Unit shall be intrinsically safe when used with barriers.
   10. Beam spread 8 degrees or less.
   11. Unit configurable via Hart and handheld programmer.
   12. Unit shall be capable of mounting in an extended nozzle without horn extending out of nozzle.
   13. Unit shall have dynamic false echo suppression for changing tank conditions.

C. Construction Features:

1. Enclosure:
    a. NEMA 4X.
    b. Enclosure Material: PBT.
2. Electrical Connection: 1/2-inch NPT.

D. Accessories:
1. Weather shield/protective cover.
2. Intrinsically safe handheld programmer.
3. 6” to 4” flange adapter.

E. Manufacturer and Model:
1. Siemens, model Sitrans LR250

2.1.2 LEVEL SWITCH - FLOAT TYPE

A. Type: Direct acting, pear shaped, eccentric weighted, displacement type liquid level sensor.

B. Construction Features:
1. Float Body: Hollow hermetically sealed, rigidly molded of polypropylene containing mechanical switch and eccentric metal weight.
2. Mechanical Switch: SPDT switch rated 16 amps resistive at 120 VAC and five amps resistive at 30 VDC.
3. Weight: Weight to cause sensor to hang straight down from cable when not immersed and only allow float to pivot when immersed in liquid.
4. Electrical Cable:
    a. Heavy duty, three conductor, flexible and submersible cable, sheathed in PVC and connected to float and switch with watertight seal.
    b. Length furnished to be sufficient to extend to junction box.

C. Manufacturer and Model:
1. Flygt, model ENM-10.

2.2 PRESSURE INSTRUMENTATION

2.2.1 PRESSURE SWITCH

A. Type: Switch assembly with diaphragm/piston pressure sensor.

B. Function: Sense gauge or differential pressure and open or close a contact when the pressure reaches the specified trip point.

C. Performance Requirements:
1. Operating Range: As specified in the Instrument Schedule.
2. Setpoint: As specified in the Instrument Schedule.
3. Setpoint Repeatability: ± 1 percent of range.

4. Output: Snap action switch, SPDT rated not less than 10 amp resistive at 120VAC and 1/2 amp resistive at 125VDC.
5. Switch and Reset Action: Adjustable deadband.
6. Adjustable Deadband Setting: As specified in the Instrument Schedule.
7. Adjustable Deadband Range: At least ± 20 percent from setting.
8. Ambient Temperature Limits: -4 to 140 degrees F.

D. Construction Features:
1. Pressure Transducer Housing and Diaphragm Materials: Coordinate with the process piping materials.
   a. Water service with copper pipe: Brass housing with Buna-N diaphragm.
   b. Other services: Type 316 stainless steel housing with Viton diaphragm.
2. Set and Reset Point Adjustments: Adjustable external adjusting nuts and pressure setting scales in psi.
3. Process Connection: 1/2 NPT.
4. Housing: Copper-free die cast aluminum, NEMA 4X.
5. External Mounting Lugs.
6. Adjusting Nuts Metal Cover with Gasket.
7. Electrical Connection: 3/4-inch NPT.

E. Manufacturer and Model:
1. Automatic Switch Company
2. Ashcroft
3. United Electric
4. Or equal.

2.2.2 PRESSURE GAUGE – BOURDON TUBE

A. Type: Bourdon Tube Pressure Element Type, Liquid Filled Gauge (for pressure ranges of 15 psi and greater and vacuum ranges to 30 inches Hg):

B. Performance Requirements:
1. Range: As specified in the Instrument Schedule.
2. Accuracy: ±0.5 percent of span (ANSI B40.1 Grade 2A).

C. Construction Features:
1. Case:
   a. Solid front design constructed of glass filled polyester.
   b. Color: Black.
2. Size: 4-1/2-inch.
3. Ring: Threaded, glass filled polyester.
4. Window: Safety glass.
5. Dial: White with black markings.
6. Filling Liquid: Silicone oil.
7. Overpressure protection: Full blowout back.

8. Bourdon Tube and Socket:
    a. Type 316 Stainless Steel.
    b. Heliarc welded unless otherwise specified.
9. Movement:
    a. 300 series Stainless Steel.
    b. Rotary geared with Teflon S coating, or cam and roller type.
    c. Built-in overload and underload movement stops.
10. Connection: 1/2-inch male NPT, bottom.
11. Mounting: Stem Mount.
12. Calibration:
    a. Adjustable pointer.
    b. Externally accessible zero adjustment.

D. Accessories:
1. Pressure Snubber: Sintered stainless steel snubber threaded into gauge socket or in external stainless steel housing with 1/4-inch NPT male and female connections.
2. Process Isolation: Provide ball valves for process isolation in accordance with the requirements of Paragraph 2.0.2 of this Section.

E. Manufacturer and Model:
1. Helicoid
2. Ashcroft
3. Wika
4. Or equal.

2.2.3 PROCESS SEAL - DIAPHRAGM TYPE

A. Type: Chemical Seal.

B. General:
1. The complete diaphragm seal assembly, including gauge, switch or transmitter, shall be factory assembled, filled and calibrated to the ranges and switch setpoints specified prior to shipment.
2. System Supplier Manufacturer shall be responsible for assuring that fill volumes and sensitivities of the supplied seals and diaphragms are suitable to provide the required gage, switch or transmitter accuracy over the specified measurement range or at switch setpoints.
3. Location and orientation of the gages, switches and seal assemblies shall be coordinated with the actual piping and equipment installations so that gages and indicators shall be easily read and accessed for maintenance by plant personnel.
4. Where field mounting and orientation conflicts arise due to incomplete coordination with field changes in the process piping and equipment installation, assemblies shall be relocated, re-oriented, re-assembled and re-calibrated as directed by Owner.

C. Construction Features:
1. Instrument Connection: 1/2-inch NPT.

2. Process Connection: 1/2-inch NPT.
3. Flushing Connection: 1/4-inch NPT.
4. Top Housing Materials: Type 316 stainless steel.
5. Process Side Housing Materials:
6. 316L Stainless Steel for metallic piping.
7. PVC or CPVC to match non-metallic piping.
8. Bolting Materials: Type 316 Stainless Steel.
9. Diaphragm, O-Rings, and Gasket Materials:

Process Fluid	Diaphragm	O-Ring	Gasket
Raw Water	316 SS	Teflon	Teflon

10. Filling Liquid: Silicone oil.
11. Working Pressure Rating: Equal to or greater than the attached gage or switch operating pressure specified in Exposed Piping Schedule in Section 15052, Exposed Piping Installation, whichever is greater.

D. Accessories:
1. Provide fill/bleed screw to permit filling of instrument and diaphragm seal.
2. Provide a clean-out ring which holds the diaphragm captive in the upper housing to allow the upper housing assembly to be removed for recalibration or cleaning of the process side housing without the loss of filling liquid or change in calibration.

E. Manufacturer and Model:
1. Helicoid
2. Wika.
3. Ashcroft
4. Or equal.

2.2.4 PROCESS SEAL – IN-LINE TYPE

A. Type: Elastomer isolated pressure sensor mounted in-line, providing full 360 degree pressure sensing, with integral mounted and filled pressure gauge and/or switch as shown on the Process and Instrumentation Diagrams and specified in the Instrument Schedule.

B. Construction Features:
1. Sensor Body and Flanges: Type 316 stainless steel.
2. Sensor Sleeve: Buna-N.
3. Sensing Liquid: Silicone filled.
4. Instrument Connection: 1/2-inch NPT.

C. Assembly and Calibration:
1. The complete pressure assembly, including gauge or switch or transmitter, shall be factory assembled, filled and calibrated to the ranges and switch setpoints specified in the Instrument Schedule prior to shipment.

2. Location and orientation of the gages, switches and pressure element assemblies shall be coordinated with the actual piping and equipment installations so that gages and indicators shall be easily read and accessed for maintenance by plant personnel.
3. Where field mounting and orientation conflicts arise due to incomplete coordination with or field changes in the process piping and equipment installation, assemblies shall be relocated, re-oriented, re-assembled and re-calibrated as directed by the Engineer.

D. Pressure Instrumentation shall be as specified herein.

E. Manufacturer and Model:
1. Ashcroft
2. Onyx Valve
3. Or equal.

2.2.5 PRESSURE TRANSMITTER

A. Type: Solid State two-wire transmitter.

B. Function: Monitor system pressures as shown and as specified in the Instrument Schedule. The transmitter shall display the monitored pressure value and shall output a 4 to 20 mADC signal proportional to the monitored pressure.

C. Performance Requirements:
1. Range: As specified in the Instrument Schedule.
2. Positive Overrange Protection: At least 1.25 times the maximum span limit.
3. Local Indication: As specified in the Instrument Schedule.
4. Accuracy (includes combined effects of linearity, hysteresis, and repeatability): ±0.10 percent of calibrated span.
5. Repeatability: 0.05 percent of calibrated span.
6. Hysteresis: 0.05 percent of calibrated span.
7. Stability (drift over a six month period): Not more than ±0.25 percent of transmitter's upper range limit.
8. Power: Designated to operate on power from receiver or remote power supply, nominal 24 VDC.
9. Supply Voltage Effect: Output change not greater than 0.005 percent of span for each one volt change in supply power.
10. Output:
    a. Isolated direct acting 4 to 20 mADC.
    b. Digital process variable signal superimposed on 4 to 20 mADC signal without compromising loop integrity
11. Ambient Temperature Limits: -20 to +180 degrees F.
12. Ambient Temperature Effect (Total Error per 100 degrees F change between the Ambient Temperature Limits): Not more than ±1.0 percent of the transmitter's upper range limit (maximum span).
13. 5 year runtime warranty.

D. Construction Features:
   1. Measuring elements protected by sealing diaphragm.
   2. Non-Wetted Parts:
      a. Body and Process Connection Bolting: Type 316 stainless steel.
      b. Housing and Cover: Die cast low copper aluminum alloy finished with epoxy paint system; covers shall be threaded and seated on Buna-N O-rings; NEMA 4 rating.
   3. Process Wetted Parts: To be compatible with the process fluid as indicated in the Instrument Schedule.
   4. Calibration Adjustments:
      a. Zero & Span: Manually adjustable, without exposing electrical components via local non intrusive push buttons, and has Hart capability.
   5. Zero Elevation and Suppression: The extent that the amount of suppression plus the calibrated span does not exceed the upper range limits of the sensor.
   6. Damping: Internal Adjustable.
   7. Built-in electrical surge and RFI protection.
   8. Electrical Conduit Connection: 1/2-inch NPT.
   9. Process Connection: 1/2-inch NPT.
   10. Provide a single shutoff valve at each process line tap to enable live process removal of transmitter.
   11. Indicator: Provide integral indicator with range in engineering units.

E. Manufacturer and Model:
   1. Siemens Sitrans P
   2. Foxboro
   4. Rosemount
   5. Or equal

2.2.6 DIFFERENTIAL PRESSURE INDICATING TRANSMITTER

A. Type: Solid State two-wire transmitter.

B. Function: Differential pressure meter shall be capable of sensing pressure from two sources. The transmitter shall display the monitored differential pressure value and shall output a 4 to 20 mADC signal proportional to the monitored differential pressure.

C. Performance Requirements:
   1. Range: As specified in the Instrument Schedule.
   2. Positive Overrange Protection: At least 1.25 times the maximum span limit.
   3. Local Indication: As specified in the Instrument Schedule.
   4. Accuracy (includes combined effects of linearity, hysteresis, and repeatability): ±0.10 percent of calibrated span.
   5. Repeatability: 0.05 percent of calibrated span.
   6. Hysteresis: 0.05 percent of calibrated span.

7. Stability (drift over a six month period): Not more than ±0.25 percent of transmitter's upper range limit.
8. Power: Designated to operate on power from receiver or remote power supply, nominal 24 VDC.
9. Supply Voltage Effect: Output change not greater than 0.005 percent of span for each one volt change in supply power.
10. Output:
    a. Isolated direct acting 4 to 20 mADC.
    b. Digital process variable signal superimposed on 4 to 20 mADC signal without compromising loop integrity.
11. Ambient Temperature Limits: -20 to +180 degrees F.
12. Ambient Temperature Effect (Total Error per 100 degrees F change between the Ambient Temperature Limits): Not more than ±1.0 percent of the transmitter's upper range limit (maximum span).
13. 5 year runtime warranty.

D. Construction Features:
1. Measuring elements protected by sealing diaphragm.
2. Capillary tube: Provide 316 S.S. Capillary tube from remote diaphragm seal to sensor.
3. Non-Wetted Parts:
    a. Body and Process Connection Bolting: Type 316 stainless steel.
    b. Housing and Cover: Die cast low copper aluminum alloy finished with epoxy paint system; NEMA 4 rating.
4. Element Type: Dual Diaphragm Seal Type
5. Process Wetted Parts: To be compatible with the process fluid as indicated in the Instrument Schedule.
6. Calibration Adjustments:
    a. Zero & Span: Manually adjustable, without exposing electrical components via local non intrusive push buttons, and has Hart capability.
7. Zero Elevation and Suppression: The extent that the amount of suppression plus the calibrated span does not exceed the upper range limits of the sensor.
8. Damping: Internal Adjustable.
9. Built-in electrical surge and RFI protection.
10. Electrical Conduit Connection: 1/2-inch NPT.
11. Process Connection: 1/2-inch NPT.
12. Indicator: Provide integral indicator with range in engineering units.
13. Provide Block and Bleed valves on the

E. Manufacturer and Model:
1. Siemens Sitrans P
2. Foxboro
3. Rosemount
4. Or equal

2.3 FLOW INSTRUMENTATION

2.3.1 VENTURI TUBE

A. General: The metering primary element shall be of the pressure differential producing type utilizing pure static pressure sensed at the inlet and throat sections.

B. Required Features:
   1. Inlet section shall be comprised of a cylindrical section, of similar diameter as the pipe, in which the high pressure tap is installed and shall incorporate to condition the flow profile before it enters the throat section.
   2. Laying length of the throat shall be at least 0.5 times the throat diameter. Low pressure tap shall be installed in this section. Outlet cone shall be truncated, having an included angle of ten degrees. Interior and exterior surfaces, except the throat, shall be coated with a two part bitumastic epoxy finish.
   3. Differential pressure shall indicate static pressure change only. Devices employing entire or partial Pitot effects, amplifying differential by changing flow direction at the point of sensing pressure, thus introducing unwanted hydraulic noise, shall not be acceptable.
   4. Tube coefficient shall be constant for pipe Reynolds number of about 50,000 and greater and independent of Beta ratio and line size.
   5. Tube shall be constructed of fabricated steel. Pressure connection for the inlet and throat section shall be Type 316 stainless steel. Throat liner shall be constructed of Type 316 stainless steel.
   6. Tube shall be provided with 150 pound flanges.
   7. Metering element shall not have debris-collecting cavities or annular chambers, but shall have a single pressure connection at the inlet and throat. In addition, a vent port and drain shall be included on a 90-degree plane to the metering tap on the inlet section.
   8. Approval data shall state and substantiate the value and tolerance of the coefficient, the effect of up and downstream piping configurations, the head loss in percent of pipe velocity head and shall provide proof that the coefficient is independent of line size and Beta ratio.
   9. Accuracy shall be ±0.75 percent of actual rate of flow. This accuracy shall be substantiated by a two times standard deviation calculation of at least thirty calibrated tube coefficients of different line size, and Beta ratio tubes or by University, Hydraulic Laboratory calibration of each flow tube.

C. Accessories:
   1. Provide a differential pressure transmitter (as specified in Article 2.2.), 5-way block and bleed valve and stainless steel capillary tubing.

D. Manufacturer and Model:
   1. Primary Flow Signal
   2. BIF
   3 Foxboro
   4. Or equal

2.4 ANALYTICAL

2.4.1 pH ANALYZER

A. Type: Continuous monitoring system consisting of pH sensor and a micro-processor-based analyzer transmitter designed to measure pH of the sample and produce a proportional output signal linear to the pH.

B. Performance Requirements:
   1. Sensor:
      a. Range: 0 to 14 pH units.
      b. Response Time: 95 percent of full scale in five seconds.
   2. Analyzer/Transmitter:
      a. Range: 0 to 14 pH units.
      b. Accuracy: 0.01 percent full scale.
      c. Repeatability: 0.01 percent of span.
      d. Stability: 0.05 percent of span for 24 hours, non-cumulative.
      e. Outputs:
         1) Two 4 to 20 mADC outputs. Individually programmable, insulated, direct acting into 0 to 600 ohms.
         2) Alarm Outputs:
            a) Four Relays with SPDT Form C contacts.
            b) Contacts rated 5A at 120 VAC.
            c) Selectable Lo-Hi, Hi-Hi, Lo-Lo.
      f. Ambient Temperature Range (Transmitter): -4 to 140 degrees F.
      g. Ambient Temperature Coefficient: Less than 0.03 percent of span per degrees C.
      h. Ambient Relative Humidity: 0 to 95 percent RH non-condensing.
      i. Analog Output Resolutions: 0.004 percent mA (12-bit) resolution.

C. Construction Features:
   1. Sensor:
      a. Wetted Materials: Chemical resistant Liquid Crystal Polymer.
      b. Body: Epoxy body, chemical resistant Liquid Crystal Polymer.
      c. Electrodes: pH and reference electrodes to be contained in sensor body.
      d. Sensor to contain thermistor for process temperature correction.
      e. Sensor to be constructed to allow refurbishing of pH 7 buffer in the standard electrode chamber.
      f. Provide submersible, flow-through sensor.
      g. Cable: PVC jacketed submersible type cable terminated in numbered spade lugs. Provide length as required to connect to remotely mounted transmitter (25 feet minimum length).
      h. Connection: Provide enlarger/reducers as required to provide a 3/4-inch NPT female connection.
   2. Analyzer/Transmitter:
      a. Microprocessor-based solid state circuitry designed for measurement of pH and transmission of proportional output signal linear to pH.

b. Built-in simulator used in conjunction with front panel controls and display to verify calibration, proper internal functioning of the analog-to-digital conversion, processing, outputs and setting up alarms.
c. Front of panel membrane sealed keypad for display control and transmitter function control testing and calibration. Front panel switch shall also allow alternate display of readouts for pH, temperature, and mA outputs.
d. Built-in Self Diagnostics: Error messages shall be presented on the display to indicate operational and equipment malfunctions. Errors shall include EPROM failure (data is not valid), scaling card not present or not recognized, analog-to-digital converter not responding, RAM failure, or internal serial communications failure.
e. Indicator: Graphical dot matrix LCD, 128x64 pixels. 1/2-inch character height.
f. Housing: NEMA 4X polycarbonate face panel, epoxy-coated cast aluminum door and case, nylon mounting bracket, and brackets to allow for handrail, surface mounting, or pipe stand mounting.
g. Power Supply: 120 VAC ±10 percent, 50/60 Hz, 10 watts.
h. Memory Backup: All configuration data shall be stored in non-volatile EEPROM.

3. Mounting:
   a. Sensor mounting:
      1) Flocculation basins outlet – Provide stainless steel slide rail assembly with stainless steel L bracket for mounting to wall.
   b. Refer to contract drawings for mounting details.

D. Accessories:
1. NEMA 4X rated 120 VAC Power On-Off selector switch as specified in Article 2.0.3, above.
2. Provide instrument (clean water) flushing nozzle, solenoid valve, and all tubing/piping necessary. Provide transmitter programming of flushing schedule (coordinate with Owner) for instrument. Include all accessories and appurtenances necessary for complete and operational flushing system.

E. Manufacturer and Model:
1. HACH, model pHd sensor with sc200 Transmitter.

2.4.2 TOC ANALYZER

A. Type: Continuous monitoring system consisting of Non-dispersive infrared (NDIR) CO2 detector and a micro-processor-based analyzer transmitter designed to measure TOC of the sample and produce a proportional output signal linear to the TOC.

B. Performance Requirements:
1. Sensor:
   a. Range: 0 to 10 mg/l TOC.
   b. Response Time: T90 $\leq$ 5 minutes

2. Analyzer/Transmitter:
    a. Range: 0 to 10 mg/l TOC
    b. Accuracy: 0.02 percent full scale.
    c. Repeatability: 0.02 percent of span.
    d. Minimum Detection Limit. ≤ 0.0015 mg/l for range 0-5 mg/l at 77 degrees F.
    e. Outputs:
        1) Two 4 to 20 mADC outputs. Individually programmable, insulated, direct acting into 0 to 600 ohms.
        2) Alarm Outputs:
            a) Five Relays with SPDT Form C contacts.
            b) Contacts rated 5A at 120 VAC.
            c) Selectable Lo-Hi, Hi-Hi, Lo-Lo.
    f. Ambient Temperature Range (Transmitter): -41 to 140 degrees F.
    g. Ambient Temperature Coefficient: Less than 0.03 percent of span per degrees C.
    h. Ambient Relative Humidity: 0 to 80 percent RH non-condensing.
    i. Analog Output Resolutions: 0.004 percent mA (12-bit) resolution

C. Construction Features:
1. Sensor:
    a. Body: PVDF body
    b. Automatic Calibration, Validation and Cleaning
    c. Provide clean, CO2 free air or Nitrogen at 2.8 to 6.2 bar(40-90psi)
    d. Sample Connection: Provide ¼-inch OD tube, compression fitting
    e. Drain Connection: Provide 1 ½-inch OD standard drain pipe
    f. UV lamp qty: up to four (but maximum of two for drinking water).
    g. Sample inlets: 2 (raw water, filtered water).

2. Analyzer/Transmitter:
    a. Microprocessor-based solid state circuitry designed for measurement of TOC and transmission of proportional output signal linear to TOC.
    b. Built-in simulator used in conjunction with front panel controls and display to verify calibration, proper internal functioning of the analog-to-digital conversion, processing, outputs and setting up alarms.
    c. Front of panel membrane sealed keypad for display control and transmitter function control testing and calibration.
    d. Built-in Self Diagnostics: Error messages shall be presented on the display to indicate operational and equipment malfunctions. Errors shall include EPROM failure (data is not valid), scaling card not present or not recognized, analog-to-digital converter not responding, RAM failure, or internal serial communications failure.
    e. Indicator: 16-Character alpha-numeric backlit display..
    f. Enclosure: NEMA 4X polycarbonate face panel, epoxy-coated and brackets to allow for surface mounting.

g. Power Supply: 120 VAC ±10 percent, 50/60 Hz, 10 watts.
h. Memory Backup: All configuration data shall be stored in non-volatile EEPROM.

D. Accessories and Options:
1. NEMA 4X rated 120 VAC Power On-Off selector switch as specified in Article 2.0.3, above.
2. Provide one year supply of all reagents and consumable required for normal operation.
3. Provide manufacturer's servicing/calibration/cleaning of equipment for a period of one year after start-up.
4. Purge air unit.
5. Provide EPA version of product.

E. Manufacturer and Model:
1. HACH, model 1950Plus On-Line TOC Analyzer

2.4.3 HIGH-RANGE TURBIDITY ANALYZER

A. Type: Continuous monitoring system consisting of a sensor and a microprocessor-based analyzer/transmitter designed to continuously measure the turbidity of liquids and produce an output signal linearly proportional to the turbidity. Unit shall utilize back scattered light type signal analysis to measure and detect the light scattered at 90 degrees of the incident light beam.

B. Performance Requirements:
1. Sensor:
a. Range: 0.01-9999.9 NTU
b. Response Time: 45 Seconds
c. Humidity: 5 to 95% non -condensing
2. Analyzer/Transmitter:
a. Range: 0.01-9999.9 NTU
b. Accuracy: ±5% from 0.01 to 2000 NTU, ±10% from 2000 to 9999 NTU
c. Repeatability: 0.01 percent of span.
e. Outputs:
1) Two 4 to 20 mADC outputs. Individually programmable, insulated, direct acting into 0 to 600 ohms.
2) Alarm Outputs:
a) Five Relays with SPDT Form C contacts.
b) Contacts rated 6A at 120 VAC.
c) Selectable Lo-Hi, Hi-Hi, Lo-Lo.
f. Ambient Temperature Range (Transmitter): -41 to 140 degrees F.
g. Ambient Temperature Coefficient: Less than 0.03 percent of span per degrees C.
h. Ambient Relative Humidity: 0 to 80 percent RH non-condensing.
i. Analog Output Resolutions: 0.004 percent mA (12-bit) resolution

C. Construction Features:
   1. Sensor:
      a. Body: NEMA 12, Corrosion-Proof
      b. Sample Connection: Provide 3/4-inch NPT tube, compression fitting
      c. Drain Connection: Provide ¾-inch NPT drain pipe
      d. All wetted parts shall be compatible with the process fluid.
      e. Sample flow rate required is 1.0 to 2.0 L/min
   2. Analyzer/Transmitter:
      a. Microprocessor-based solid state circuitry designed for measurement of Turbidity and transmission of proportional output signal linear to Turbidity.
      b. Built-in simulator used in conjunction with front panel controls and display to verify calibration, proper internal functioning of the analog-to-digital conversion, processing, outputs and setting up alarms.
      c. Front of panel membrane sealed keypad for display control and transmitter function control testing and calibration.
      d. Built-in Self Diagnostics: Error messages shall be presented on the display to indicate operational and equipment malfunctions. Errors shall include EPROM failure (data is not valid), scaling card not present or not recognized, analog-to-digital converter not responding, RAM failure, or internal serial communications failure.
      e. Indicator: 16-Character alpha-numeric backlit display..
      f. Enclosure: NEMA 4X polycarbonate face panel, epoxy-coated and brackets to allow for surface mounting.
      g. Power Supply: 120 VAC ±10 percent, 50/60 Hz, 10 watts.
      h. Memory Backup: All configuration data shall be stored in non-volatile EEPROM.

D. Accessories:
   1. NEMA 4X rated 120 VAC Power On-Off selector switch as specified in Article 2.0.3, above.

E. Manufacturer and Model:
   1. HACH, model Surface Scatter 7 sc High Range with sc100.

2.4.4 LOW-RANGE TURBIDITY ANALYZER

A. Type: Continuous monitoring system consisting of a sensor and a microprocessor-based analyzer/transmitter designed to continuously measure the turbidity of liquids and produce an output signal linearly proportional to the turbidity.

B. Measurement Principle: Meets USEPA method 180.1 regulation. Instrument detects the light scattered at 90° of the incident light beam.

C. System Sensor Performance Requirements:
   1. Sample Flow Rate: 3.1 to 11.9 GPH.
   2. Ambient Temperature: 32 to 122 degrees Fahrenheit.

3. Measuring Range: 0.001-100 NTU.
4. Output Range: As specified in the Instrument Schedule.
5. Sensitivity: 0.001 NTU.
6. Repeatability: ±1.0% of reading or ±0.002 NTU, whichever is greater.
7. Response Time: Initial response in 1 minute, 15 seconds or less.
8. Accuracy:
    a. 0 to 40 NTU: ±2% of reading or ±0.020 NTU (whichever is greater).
    b. 40 to 100 NTU: ±5% of reading.

D. System Analyzer/Transmitter Performance Requirements:
1. Power Requirements: 120 VAC, 60 Hz.
2. Display: Graphic dot matrix LCD, 128 x 64 pixels with LED backlighting.
3. Relays: Three SPDT, user-configurable contacts rated 100 to 230 VAC, 5 Amp resistive maximum.
4. Outputs: Two analog 4-20 mA, maximum impedance 500 Ohms.
5. Alarms: Low alarm point, low alarm point deadband, high alarm point, high alarm point deadband, off delay, and on delay.
6. Memory Backup: All user settings are retained indefinitely in memory with EEPROM.

E. Construction Features:
1. Housing: NEMA 4X enclosure with integral shielded cable to the analyzer/transmitter. Equip enclosure with stainless steel hardware for surface or pipe stand mounting as required.
2. Bubble Trap: Integral bubble trap to eliminate air in the sample.
3. Process Connections: 1/4 inch NPT female.
4. Analyzer/Transmitter:
    a. Housing: NEMA 4X corrosion-resistant polystyrene with stainless steel hardware for surface, wall, or pipe stand mounting as required.
    b. Configuration: Panel keypad for configuration, calibration, and diagnostics. All user settings shall be retained in memory. Configuration values shall be password protected.

F. Accessories:
1. Mounting hardware: 1/4 inch PVC tubing connection to analyzer, and 3/4 inch hose bib, piping, needle valve, and fittings for connection to isolation solenoid valve as required for installation as shown on the Drawings.

G. Manufacturer and Model:
1. HACH, model 1720e with sc200.

2.5 SPARE REPLACEMENT UNITS AND PARTS

A. Spare replacement instruments and components shall be provided for the field mounted instruments as follows:

1. Ten spare fuses of each type and size used in the instruments and in control panels
2. Two spare pressure gauges for each type/size used.
3. One spare analytical probe for each type used.

B. All spare parts shall be identical and interchangeable with similar parts furnished under this Section.

C. All spare parts shall be individually packaged for long-term storage, and for protection against impact, moisture, and dirt. Each package shall be clearly labeled as to its contents with a description and part number.

D. All spare parts shall become the property of the Owner. The Contractor shall maintain the spare parts inventory as listed above, and replace, at no additional cost, all spare parts consumed during the one-year warranty period.

2.6 INSTRUMENT SCHEDULE

A. The Instrument Schedule is included at the end of this Section.

B. Information specific to the various field and associated panel mounted instruments is listed in the Schedule.

C. Listings for the following instruments and control devices have not been included because their pertinent aspects are covered in Section 13440, Panel Mounted Instruments, of the Specifications and/or are depicted on the Contract Drawings:
1. Pushbuttons, selector switches, and indicating lights.
2. Control relays and timers.
3. Digital indicators.

D. Every effort has been made to include specific information for the primary sensors and field instruments. However, some items may have been inadvertently omitted. If information for any instrument has not been included in the Schedule, Contractor shall verify requirements with Engineer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Contractor shall require the system supplier to furnish the services of qualified factory-trained servicemen to assist in the installation of the instrumentation and control system equipment.

B. Install each item in accordance with manufacturers' recommendations and in accordance with the Contract Documents. Transmitters and instruments, which require access for periodic calibration or maintenance, shall be mounted so they are accessible while standing on the floor. Care shall be taken in the installation to ensure sufficient space is

provided between instruments and other equipment or piping to allow for easy removal and servicing.

C. All items shall be mounted and anchored using stainless steel hardware unless otherwise noted.

D. All field instruments shall be rigidly secured to walls, stands or brackets as required by the manufacturer and as shown on the Contract Drawings.

E. Conform to all applicable provisions of the NEMA standards, NEC and local, State and Federal codes when installing the equipment and interconnecting wiring.

3.2 START-UP, CALIBRATION, AND TESTING AND TRAINING

A. Comply with the requirements of Section 13401, Instrumentation and Control System General Requirements.

+ + END OF SECTION +

INSTRUMENT INDEX

LOOP NUMBER	LOOP DESCRIPTION	INSTRUMENT LOCATION	CALIBRATED RANGE	SETPOINT	LINE SIZE	SPEC.
ANALYTICAL INSTRUMENTATION						
AE/AIT - G0201	INFLUENT pH/TEMPERATURE	FLOCCULATION CHAMBER OUTLET	0-14 pH	--	--	13420-2.4.1
AE/AIT - G0200	RAW WATER TURBIDITY	RAPID MIXERS INLET	0-999.9 NTU	--	--	13420-2.4.3
AE/AIT - G0700	GAC TREATED WATER TURBIDITY	UV INFLUENT	0.00-2.00 NTU	--	--	13420-2.4.4
AE/AIT - G0701	UV NO. 1 TRANSMITTANCE	UV REACTOR NO.1	70% - 100%	--	--	EXIST
AE/AIT - G0702	UV NO. 2 TRANSMITTANCE	UV REACTOR NO.2	70% - 100%	--	--	EXIST
AE/AIT - G0500	GAC VESSELS COMMON DISCHARGE EFFLUENT TOC	GAC VESSELS	0-10 mg\l	--	--	13420-2.4.2
FLOW INSTRUMENTATION						
FE/FIT - G0200	FTWR WATER INFLUENT FLOW	FTWR INFLUENT FLOWMETER VAULT	0-1,000 gpm	--	12”	13420-2.3.1
FE/FIT - G0201	RAW WATER INFLUENT FLOW	RAW INFLUENT FLOWMETER VAULT	0 – 1 3 MGD	--	24”	13420-2.3.1
FE/FIT - P0100	GAC FEED PUMPS DISCHARGE FLOW	GAC FEED PUMPS	0 – 1 3 MGD	--	24”	13420-2.3.1
FE/FIT - G0400	GAC BACKWASH PUMP DISCHARGE FLOW	GAC BACKWASH	0-1,500 gpm	--	10”	13420-2.3.1
FE/FIT - G0401	SECONDARY BACKWASH WATER FLOW	GAC BACKWASH	0-1,500 gpm	--	10”	13420-2.3.1
FE/FIT - G0511	GAC VESSEL (PV-1N) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0611	GAC VESSEL(PV-1S) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0521	GAC VESSEL (PV-2N) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0621	GAC VESSEL (PV-2S) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0531	GAC VESSEL (PV-3N) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0631	GAC VESSEL (PV-3S) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900

LOOP NUMBER	LOOP DESCRIPTION	INSTRUMENT LOCATION	CALIBRATED RANGE	SETPOINT	LINE SIZE	SPEC
FE/FIT - G0541	GAC VESSEL(PV-4N) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0641	GAC VESSEL (PV-4S) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0551	GAC VESSEL (PV-5N) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0651	GAC VESSEL (PV-5S) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0561	GAC VESSEL (PV-6N) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0661	GAC VESSEL (PV-6S) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0571	GAC VESSEL (PV-7N) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
FE/FIT - G0671	GAC VESSEL (PV-7S) INFLUENT FLOW	GAC VESSELS	0-700 gpm	--	8”	11900
LEVEL INSTRUMENTATION						
LE/LIT - P0100	GAC FEED PUMP STATION WETWELL LEVEL	GAC FEED PUMP STATION	0.0 - 15.5 ft (El. 509.0 - 524.5’)	--	4” flange	13420-2.1.1
LE/LIT - G0800	GAC EQUALIZATION BASIN LEVEL	GAC EQUALIZATION BASIN	0.0 –10.5’ (El. 512.5 - 523.0’)	--	4” flange	13420-2.1.1
LSH - P0100	GAC FEED PUMP STATION WETWELL	GAC FEED PUMP STATION	--	El. 522.50’	--	13420-2.1.2
LSL - 0199	FTWR VAULT FLOOD	FTWR VAULT SUMP	--	El. 522.47’	--	13420-2.1.2
LSL - P0100	GAC FEED PUMP STATION WETWELL	GAC FEED PUMP STATION	--	El. 514.50’	--	13420-2.1.2
LSH - G0800	GAC EQUALIZATION BASIN	GAC EQUALIZATION BASIN	--	El. 519.75’	--	13420-2.1.2
LSL - G0800	GAC EQUALIZATION BASIN	GAC EQUALIZATION BASIN	---	El. 513.5’	--	13420-2.1.2
PRESSURE INSTRUMENTATION						
PI - G0411	BACKWASH PUMP NO. 1 DISCHARGE PRESSURE	BACKWASH PUMP NO. 1	0-50 PSI	--	--	13420-2.2.2
PI - G0400	BACKWASH MAKUP WATER PRESSURE	GAC BACKWASH	0-250 PSI	--	--	13420-2.2.2

LOOP NUMBER	LOOP DESCRIPTION	INSTRUMENT LOCATION	CALIBRATED RANGE	SETPOINT	LINE SIZE	SPEC
PI - G0401	BACKWASH MAKUP WATER PRESSURE	GAC BACKWASH	0-250 PSI	--	--	13420-2.2.2
PI - G0402	BACKWASH MAKUP WATER PRESSURE	GAC BACKWASH	0-250 PSI	--	--	13420-2.2.2
PI - G0500	GAC VESSELS (PV-1N & PV-1S) COMMON INFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0511	GAC VESSEL (PV-1N) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0611	GAC VESSEL (PV-1S) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0501	GAC VESSELS (PV-2N & PV-2S) COMMON INFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0521	GAC VESSEL (PV-2N) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0621	GAC VESSEL (PV-2S) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0502	GAC VESSELS (PV-3N & PV-3S) COMMON INFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0531	GAC VESSEL (PV-3N) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0631	GAC VESSEL (PV-3S) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0503	GAC VESSELS (PV-4N & PV-4S) COMMON INFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0541	GAC VESSEL (PV-4N) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0641	GAC VESSEL (PV-4S) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0504	GAC VESSELS (PV-5N & PV-5S) COMMON INFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0551	GAC VESSEL (PV-5N) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	---	--	11900
PI - G0651	GAC VESSEL (PV-5S) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	---	--	11900
PI - G0505	GAC VESSELS (PV-6N & PV-6S) COMMON INFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0561	GAC VESSELS (PV-6N) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0661	GAC VESSEL (PV-6S) EFFLUENT PRESSURE	GAC VESSLES	0 – 125 PSIG	--	--	11900

LOOP NUMBER	LOOP DESCRIPTION	INSTRUMENT LOCATION	CALIBRATED RANGE	SETPOINT	LINE SIZE	SPEC
PI - G0506	GAC VESSELS (PV-7N & PV-7S) COMMON INFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0571	GAC VESSEL (PV-7N) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0671	GAC VESSEL(PV-7S) EFFLUENT PRESSURE	GAC VESSELS	0 – 125 PSIG	--	--	11900
PI - G0800	EQ PUMPS COMMON DISCHARGE PRESSURE	GAC EQUALIZATION BASIN	0-20 PSIG	--	--	13420-2.2.2
PE/PI/PSH - G0311	RESIDUAL PUMP NO. 1 DISCHARGE PRESSURE	RESIDUAL PUMP NO. 1	0-100 PSIG	--	--	13420-2.2.1/2/4
PE/PI/PSH - G0312	RESIDUAL PUMP NO. 2 DISCHARGE PRESSURE	RESIDUAL PUMP NO. 2	0-100 PSIG	--	--	13420-2.2.1/2/4
PE/PIT - G0400	BACKWASH PUMPS DISCHARGE PRESSURE	BACKWASH PUMPS	0-50 PSIG	--	--	13420-2.2.5
PI/PSH - P0111	GAC FEED PUMP NO. 1 DISCHARGE PRESSURE	GAC FEED PUMP NO. 1	0-50 PSIG	25 PSIG	--	13420-2.2.1/2
PI/PSH - P0112	GAC FEED PUMP NO. 2 DISCHARGE PRESSURE	GAC FEED PUMP NO. 2	0-50 PSIG	25 PSIG	--	13420-2.2.1/2
PI/PSH - P0113	GAC FEED PUMP NO. 3 DISCHARGE PRESSURE	GAC FEED PUMP NO.3	0-50 PSIG	25 PSIG	--	13420-2.2.1/2
PDIT - G0511	GAC VESSEL (PV-1N) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0611	GAC VESSEL (PV-1S) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0521	GAC VESSEL (PV-2N) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0621	GAC VESSEL (PV-2S) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0531	GAC VESSEL (PV-3N) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0631	GAC VESSEL (PV-3S) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0541	GAC VESSEL (PV-4N) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0641	GAC VESSEL (PV-4S) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900

LOOP NUMBER	LOOP DESCRIPTION	INSTRUMENT LOCATION	CALIBRATED RANGE	SETPOINT	LINE SIZE	SPEC
PDIT - G0551	GAC VESSEL (PV-5N) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0651	GAC VESSEL (PV-5S) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0561	GAC VESSEL (PV-6N) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0661	GAC VESSEL (PV-6S) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0571	GAC VESSEL (PV-7N) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
PDIT - G0661	GAC VESSEL (PV-7S) DIFFERENTIAL PRESSURE	GAC VESSELS	0-125 PSIG	--	--	11900
MISCELLANEOUS INSTRUMENTATION						
UAH - G0301	TORQUE SWITCH HIGH (ALARM)	SEDIMENTATION BASIN NO. 1 DRIVE MOTOR	PER DIV. 11 MFG.	--	--	11225
XAH - G0301	TORQUE SWITCH OVERLOAD	SEDIMENTATION BASIN NO. 1 DRIVE MOTOR	PER DIV. 11 MFG.	--	--	11225
UAH - G0302	TORQUE SWITCH HIGH (ALARM)	SECONDARY CLARIFIER NO. 3 DRIVE MOTOR	PER DIV. 11 MFG.	--	--	11225
XAH - G0302	TORQUE SWITCH OVERLOAD	SECONDARY CLARIFIER NO. 4 DRIVE MOTOR	PER DIV. 11 MFG.	--	--	11225
XSL/XIT - G0311	PRESENCE/ABSENCE DETECTOR	RESIDUAL PUMP NO.1	PER DIV. 11 MFG.	PER DIV. 11 MFG.	6”	11125
XSL/XIT - G0312	PRESENCE/ABSENCE DETECTOR	RESIDUAL PUMP NO.2	PER DIV. 11 MFG.	PER DIV. 11 MFG.	6”	11125

SECTION 13430

CONTROL PANELS AND ENCLOSURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope of Work:
   1. CONTRACTOR shall furnish, install, test, and place into satisfactory operation the control panels, enclosures, and panel devices as shown on the Drawings and specified herein.
   2. Operational and functional requirements for the various panels are shown in control schematics, pneumatic diagrams, and/or functional instrumentation diagrams on the Instrumentation (I) drawings and Electrical (E) drawings.
   3. The Drawings and Specifications illustrate and specify functional and general construction requirements of the panel components and do not necessarily show or specify all components, wiring, piping, and accessories required to make a completely integrated system. CONTRACTOR shall provide all piping, wiring, accessories, and labor required for a complete, workable, and integrated system.

1.2 QUALITY ASSURANCE

A. Standards, Codes and Regulations:
   1. Construction of panels and the installation and interconnection of all equipment and devices mounted within shall comply with applicable provisions of the following standards, codes, and regulations:
      a. National Electrical Code (NEC).
      b. National Electrical Manufacturer's Association (NEMA) Standards.
      c. Institute of Electrical and Electronics Engineers, Inc (IEEE).
      d. Local and State Building Code.
      e. Operational Safety and Health Administration (OSHA) Regulations.
      f. American Society for Testing and Materials (ASTM).
      g. Where any conflict arises between codes or standards, the more stringent requirement shall apply.
   2. All electrical materials and equipment shall be new and shall bear the label of the Underwriters Laboratory (UL), Inc., Factory Mutual (FM) or equivalent where standards have been established and label service regularly applies.
   3. Control panels must be designed and assembled in a shop that is a member of UL's custom builder program and that has ability to apply the UL Listing Mark to the finished product.

B. Acceptable Manufacturers:
   1. Furnish panel instruments and devices by the named manufacturers or equal equipment by other manufacturers, if so listed.

2. The named manufacturers have been specified to establish the standard of quality and performance of the equipment to be supplied.
3. Obtain all instruments or devices of a given type from the same manufacturer.

C. General Design Requirements:
1. Comply with the requirements of Section 13401, Plant Monitoring and Control System General Requirements.

D. Factory Assembly and Testing:
1. Fully assemble and test each enclosure and panel at the factory prior to shipment, demonstrating that all specified functions are performed.
2. Comply with the requirements of Section 13402, Plant Monitoring and Control Factory Testing.

1.3 SUBMITTALS

A. Comply with the requirements of Section 13401, Plant Monitoring and Control System General Requirements.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements of Section 13401, Plant Monitoring and Control System General Requirements.

PART 2 - PRODUCTS

2.1 GENERAL CONSTRUCTION REQUIREMENTS

A. Provide all electrical and/or pneumatic components and devices, support hardware, fasteners, interconnecting wiring and/or piping required to make the control panels complete and operational units. Provide bulkhead fittings for ail air piping and tubing penetrating control enclosures.

B. Locate and install all devices and components so that connections can be easily made and so that there is ample room for servicing each item.

C. Components for installation on panel exterior shall be located as shown on the Drawings. Layouts shall be submitted for approval as per Section 13401, Plant Monitoring and Control System General Requirements. All exterior panel mounted instruments shall have a NEMA rating equal to the enclosure. For devices that cannot be obtained with a NEMA rating equal to the enclosure, mount the device behind a transparent viewing window as specified below. The window shall maintain the NEMA rating of the enclosure.

D. Where permitted by location and layout as shown on the Drawings, all panels and enclosures shall have full height rear access doors. Where rear doors are not possible, panels shall have full height front access doors.

E. Adequately support and restrain all devices and components mounted on or within the panel to prevent any movement.

F. Provide subpanels for installation of all internally mounted components. All free standing control panels shall include full height rear and side subpanels, where enclosure layout permits. All wall mounted, frame mounted, and floor mounted enclosures shall include full height rear subpanels.

G. Provide mounting strips for installation of all relays and other components where mounting strips are practical.

H. All wiring to panel connections from field instruments, devices, and other panels shall be terminated at master numbered terminal strips, unless otherwise specified.

I. Provide the following convenience accessories listed below inside of each free-standing control panel. The accessories are shown as the "utility circuit" on the Contract Drawings and shall have their own circuit breaker and separate power feed.
   1. At least one 120 VAC, 15A duplex, grounding type receptacle.
   2. One or more 120 VAC fluorescent light fixtures with minimum 40 watt lamp and protective plastic shield, as required to span across a minimum of two-thirds of the panel width.
   3. One 120 VAC, 15A, snap switch in an outlet box with a cover to turn on the light. The switch shall be located so that it is easily accessible from the door.

J. The bottom 12 inches of free standing panels shall be free of all devices unless otherwise indicated, including terminal strips, to provide ease of installation and testing.

K. Front panel indication and control devices shall be mounted within a range of 42 to 68 inches above the operating floor. No indication or control devices shall be mounted less than 36 inches above the operating floor level unless otherwise specified or shown on the Drawings.

2.2 IDENTIFICATION

A. Provide laminated plastic nameplates and legend plates for identification of panels, enclosures, and components mounted thereon as follows:
   1. Nameplates shall be of 3/32 thick laminated phenolic type with white matte finish and black letter engraving.
   2. Panel identification nameplates to have 1/2-inch high letter engravings.
   3. Panel mounted component identification (i.e. control devices, indicating lights, selector switches, etc.) nameplates and legend plates to have 1/4 inch high letter engravings, unless otherwise noted on the Drawings.
   4. Nameplates shall be attached to the panel face with two stainless steel self-tapping screws and self-backed adhesive.

5. Nameplate engravings shall include the descriptive title indicated on the Drawings and Specifications.

B. Tag all panel mounted instruments in accordance with Section 13420, Primary Sensors and Field Instruments, Paragraph 2.0.1.

C. Tag all electrical components and devices mounted within control panel enclosures with engraved nameplates as specified in Paragraph 2.2.A. above. Tag all door-mounted devices on the rear of the door with engraved nameplates as specified in Paragraph 2.2.A. above. All interior panel nameplates shall be attached with self-backed adhesive.

D. Tag all pneumatic lines with plastic tags. Paper tags are not acceptable.

E. Numerically code terminals on terminal strips.

F. Match existing wiring color code. Where no such code exists, color code and/or numerically code wiring as required by applicable standards. Wires shall be identified at each end with permanent alphanumeric codes as specified below. All wiring not de-energized by the panel disconnect or circuit breaker shall be orange wire.

G. For all panels containing wiring not de-energized by the panel disconnect or circuit breaker, provide a warning nameplate on the front of the panel stating "WARNING: ORANGE WIRING NOT DE-ENERGIZED BY PANEL DISCONNECT". The nameplate shall be orange with black, 1/4-inch high letter engravings and shall be attached to the panel face with stainless steel screws and adhesive.

2.3 PANELS AND ENCLOSURES

A. General:
   1. Panels and enclosures shall meet the NEMA requirements for the type specified and/or as shown on the Drawings.
   2. Sizes shown on the Drawings are estimates. CONTRACTOR shall furnish enclosures of the size required to house all equipment, instruments, front panel mounted devices, power supplies, power distribution panels, wiring, tubing, and other components installed in the enclosures.

B. Construction Features:
   1. All control panels shall be fabricated in accordance with the NEMA ratings specified and/or as shown on the Drawings.
      a. Provide lifting eye bolts to facilitate handling of the enclosures, where enclosure size requires. Bolt lifting eyes directly to the enclosure structural members.
      b. Continuously weld all exterior seams and grind smooth. Surface grind complete removal of corrosion, burrs, sharp edges, and mill scale.
      c. Reinforce sheet steel with steel angles where necessary to adequately support equipment and ensure rigidity and to preclude resonant vibrations.

d. Panel shall be flat within 1/16-inch over a 24-inch by 24-inch area, or flat within 1/8-inch for a larger surface. Flatness shall be checked by using a 72-inch long straight edge. Out-of-flatness shall be gradual, in one direction only, and shall not consist of obvious depressions or a series of wavy sections.
e. Use pan type construction for doors. Door widths shall not exceed 36 inches.
f. Mount doors with full-length heavy-duty piano hinge with stainless steel hinge pins.
g. Provide oil resistant gasket completely around each door or opening.
h. Use stainless steel fasteners throughout.
i. Provide interior mounting panels and shelves constructed of minimum 12-gauge steel with a white enamel finish. All free-standing control panels shall include full height rear and side subpanels where enclosure layout permits. All wall mounted, frame mounted, and floor mounted enclosures shall include full height rear subpanels.
j. Provide steel print pocket with white enamel finish.
k. Provide enclosure mounting supports and/or bases as required for floor, frame, or wall mounting and for free standing enclosures.
l. All panels outside of control rooms shall have solid bottoms.
m. Provide all holes and cutouts for installation of conduit and equipment. Cable and piping shall enter the enclosure through the bottom unless otherwise noted. All conduit and piping openings and all conduits shall be sealed watertight.

2. Control panels located in control or electrical room areas shall be NEMA 12 rated unless otherwise noted on the Drawings.
   a. Fabricate enclosures using minimum 14-gauge steel for wall or frame mounted enclosures and minimum 12-gauge for floor mounted and free standing enclosures. Steel shall be free of pitting and surface blemishes.
   b. For floor mounted enclosures, provide minimum 12-gauge steel floor stand kits bolted to the bottom of the enclosure and sealed and gasketed to maintain NEMA 12 rating. Floor stand heights shall be coordinated with enclosure sizes and base pads so as to comply with the general indication and control device mounting height requirements as specified herein and/or as shown on the drawings. Floor stands shall be mounted on base pads using anchor bolts and/or expansion anchors as specified in Paragraph 2.3.3.g below.
   c. Free-standing enclosures shall be constructed with an integral fully enclosed solid bottom section at least 6 inches in height from the bottom of the enclosure to the bottom edge of the enclosure door opening. Free-standing enclosures shall be mounted on base pads as specified in Part 3 below.
   d. Provide handle-operated, oil-tight, key-lockable three-point stainless steel latching system with rollers on latch-rods for easy door closing.
   e. Completely clean all interior and exterior surfaces so they are free of corrosive residue, oil, grease, and dirt. Zinc phosphatize for corrosion protection.
   f. One coat of primer shall be applied to all interior and exterior surfaces immediately after corrosion protection has been applied. Exterior surfaces shall then be given sufficient coats of primer surfacer, applied with sanding and cleaning between coats, until a Grade 1 finish can be produced on the finish coat.

g. All interior surfaces shall be painted with two coats of semi-gloss white enamel.
h. All exterior surfaces shall be painted with a minimum of three finish coats of enamel to ultimately produce a Grade 1 finish (super smooth; completely free of imperfections). Color to be selected by ENGINEER from complete selection of standard and custom color charts furnished by the manufacturer.
i. Primer and finish paint shall be compatible and shall be a low VOC, high solids polyurethane enamel as manufactured by Sherwin Williams, or equal.
j. Provide one extra quart of touch-up paint for each exterior finish color.
k. Provide mounting bracket or shelf for UPS (where present).

3. All panels located outside, or as identified on the Drawings shall be NEMA 4X rated stainless steel.
   a. Panels shall be Type 304 stainless steel construction. Fabricate enclosures using minimum 14-gauge stainless steel for wall or frame mounted enclosures and minimum 12-gauge for floor mounted and free standing enclosures. Steel shall be free of pitting and surface blemishes. Panel shall be white polyester urethane coated from the factory to reduce solar heat load.
   b. Provide stainless steel fast-operating clamp assemblies on three sides of each door.
   c. Provide a rolled lip around three sides of door and along top of enclosure.
   d. Provide a hasp and staple for padlocking. Provide padlock for each enclosure, all keyed alike.
   e. Provide custom fabricated sun shields for all outdoor panels, as specified.
      1) Sun shields shall be fabricated from minimum 10 gauge aluminum, and shall be designed, fabricated, installed and supported to fully cover and shade the top, sides and back of the enclosure, and to partially shade the front panel of the enclosure, from direct exposure to sunlight from sunrise to sunset.
      2) Sun shields shall not be attached directly to the enclosure by drilling holes through, or welding studs to, the enclosure surfaces, and shall be designed and mounted to provide a minimum 1 inch air gap all around the enclosure for air circulation and heat dissipation.
      3) The top section of all sun shields shall be sloped at a minimum angle of 5 degrees from horizontal. For wall-mounted enclosures, the top section shall slope downward away from the wall and towards the front of the enclosure. For free standing, floor mounted and frame mounted enclosures the top section shall slope downward towards the backside of the enclosure.
      4) The front edge of the top section of all sun shields shall incorporate a narrow and more steeply sloped drip shield segment which sheds water away from the front of the enclosure and prevents it from dripping and/or running directly onto the front panel of the enclosures.
      5) All seam welds used in sun shield fabrication shall be continuous and shall be ground smooth.
      6) All exposed corners, edges and projections shall be smooth rounded or chamfered to prevent injury.
      7) CONTRACTOR shall submit detailed sun shield fabrication and support drawings with the enclosure shop drawings for review and approval.

f. Provide a clear plastic, NEMA 4X, gasketed, lockable, hinged door to encompass all non-NEMA 4X front of panel instruments.
g. Free standing enclosures shall be constructed with an integral fully enclosed solid bottom section at least 6 inches in height from the bottom of the enclosure to the bottom edge of the enclosure door opening. Free-standing enclosures shall be mounted on base pads as specified below.

2.4 ELECTRICAL SYSTEMS

A. Control of Environment (refer to Section 13401, Plant Monitoring and Control System General Requirements, Paragraph 1.7.D. for ambient temperature design criteria):
   1. Outdoor Panels:
      a. Provide adequately sized automatically controlled heaters to maintain temperature inside each enclosure above the minimum required for component operation and to prevent/control interior condensation.
      b. Provide automatically controlled closed loop heat exchangers or closed loop air conditioners with filtered air louvers if required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the enclosure. Panel cooling components shall maintain the NEMA rating of the enclosure.
      c. Provide internal corrosion inhibitor devices at a rate of twice the recommended amount in all panels. Provide spare two-year quantity (assuming one change/year). Provide Hoffman HCI Series or equal.
   2. Indoor Panels:
      a. Provide adequately sized automatically controlled heaters to maintain temperature approximately 10 degrees F above ambient for condensation prevention inside panels.
      b. Provide automatically controlled closed loop heat exchangers or closed loop air conditioners with filtered air louvers if required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the enclosure. Panel cooling components shall maintain the NEMA rating of the enclosure.
      c. Provide internal corrosion inhibitor devices at a rate of twice the recommended amount in all panels. Provide spare two-year quantity (assuming one change/year). Provide Hoffman HCI Series or equal, for corrosion control inside of each enclosure.
   3. Panel heaters shall be thermostatically controlled, fan-driven heaters, with all components mounted in an anodized aluminum housing for sub-panel mounting. The heaters shall be powered from 120 VAC from a dedicated circuit breaker and shall be Hoffman Bulletin D-85, or equal.
   4. Heat exchangers and air conditioners shall be of a dual loop design to isolate panel interior air from exterior air. The units shall be thermostatically controlled and shall be powered from 120 VAC from a dedicated circuit breaker. The units shall be Hoffman Bulletin D-85, or equal.

B. Power Source and Internal Power Distribution:

1. General: Control panel power supply source type, voltage, number of circuits and circuit ratings shall be as shown on the Electrical Drawings.
2. The panels and enclosures shall be provided with internal 120 VAC DIN rail mounted circuit breakers sized as required to distribute power to the panel components. Provide quantity of circuits as shown on the Drawings or as required. Circuit breakers shall be Allen Bradley Bulletin 1492-CB, 1492-GH, or equal. Each panel and enclosure shall contain two spare circuit breakers minimum. Provide a durable legend mounted near the circuit breakers in each panel which lists the circuit breaker numbers and functional descriptions.
3. Provide DC power supplies of quantities and sizes as required for powering DC signal and control loops.
4. Provide surge suppressors on all power sources as required to protect against damage from electrical surges.

C. Electrical Wiring and Accessories:
1. Unless otherwise specified, internal wiring shall be Type THHN stranded copper wire with thermoplastic insulation rated for 600-volts at 85 degrees C for single conductors, color coded and labeled with wire identification.
2. For DC signal wiring, use No. 16 minimum AWG twisted pairs with overall shield.
3. For AC power wiring, use No. 12 minimum AWG. For AC and DC signal and control wiring, use No. 16 minimum AWG. For wiring carrying more than 15 amps, use sizes required by NEC and IEEE standards.
4. Install wiring runs in wire troughs along horizontal or vertical routes to present a neat appearance. Angled runs are not acceptable.
5. Separate and shield DC signal wiring from power and control wiring by a minimum of 4 inches, using separate wire troughs.
6. Where possible or practical in the panels and enclosures, route the low voltage DC signal wiring along the right portion of the enclosure subpanel(s) and route the AC power and control wiring to the left portion of the subpanel(s), with the incoming power and distribution circuit breakers located to the upper left.
7. Group or bundle parallel runs of wire using covered troughs. Maximum bundle size to be 1 inch. Troughs shall be filled to only 40 percent capacity. Separate troughs shall be used for internal wiring and external (field) wiring.
8. Adequately support and restrain all wiring runs to prevent sagging or other movement.
9. Terminal Blocks:
    a. Terminate all field wiring and internal panel wiring at 600 V barrier type terminal blocks, Phoenix Contact UK 3, Allen-Bradley 1492-J3 or equal.
    b. Terminal blocks shall be tubular screw type with pressure plate capable of accepting #24-#12 wires and shall be mounted on DIN rail. DIN rail by terminal block manufacturer or equal.
    c. End anchors shall be provided on both ends of all terminal strips to firmly anchor the terminal blocks to the mounting rail and insulating end barriers shall be provided on one end of the terminal strip as necessary. End anchors by terminal block manufacturer or equal.

d. No more than two wires shall be terminated at any single screw. Provide jumpers as required to join adjacent terminal blocks for additional wiring connection points.
e. All terminal blocks shall be labeled with permanently affixed numeric identifiers on each block. Identifiers shall be self-stick plastic tape strips with permanent, machine printed numbers.
f. Provide a separate terminal block for landing each analog signal cable shield.
g. Provide separate terminal strips for DC signal and AC power wiring.
h. Provide spare terminal blocks equal in number to 20 percent of the terminals used for each type of wiring (i.e., DC signal and AC power).

10. Panel Front Face Port Interface:
    a. Equip Control Panels containing an Ethernet switch, or where indicated on the Drawings, with a 120 VAC power outlet rated for at least 3A with a front panel mounted RJ-45 Ethernet jack.
    b. Interface module shall have a dust cover with securing latch, for protection against dust and splashing water. Installation shall maintain the NEMA rating of the panel.
    c. Power external GFCI outlet from a detailed circuit breaker inside the panel.
    d. Provide Category 5 cable internally from the RJ-45 interface to the Ethernet switch.
    e. Manufacturer and Model: Phoenix Contact HEAVYCON 5604431.
    f. Or equal.
11. Wire Markers:
    a. All panel wires and field wires shall have an alphanumeric identification tag at each point of termination.
    b. Where practical, wire numbers shall be unique and continuous. Where wire numbers change, the appropriate drawings shall include both wire numbers, clearly indicated, at the point of transition.
    c. Each wire number shall be solid, machine printed, and not pieced from other single and/or double-digit tags.
    d. Wire markers shall be heat, oil, water, and solvent resistant, vinyl, self-laminating, self-adhesive, wrap type labels as manufactured by the W.H. Brady Co. or equal.
    e. All wire labels shall be clearly visible and not hidden by wire duct or other components in the enclosures.
12. All wiring shall be installed such that if wires are removed from any one device, power will not be disrupted to any other device.
13. All alarms generated external to the panel, spare alarm, and repeat contacts shall be wired out to terminal blocks.
14. Use separate, isolated 5/16-inch diameter copper grounding studs or 1/4 inch thick drilled and tapped copper bus bars for instrument signal cable shield grounding connections and instrument power/equipment grounding system. Shield grounds shall be completely isolated from the enclosure instrument power/equipment grounds.
15. Where wires pass through panel walls, provide suitable bushings to prevent cutting or abrading of insulation.

16. When DC power and/or low voltage AC power is required, provide and install the necessary power supplies and transformers in the panel.
17. Provide circuit breakers to protect each circuit, with no more than six instruments on a single circuit.
18. Provide surge suppressors on all signal wiring in both the field and in the panel for all signals entering or leaving the building or running between buildings, as required to protect against damage from electrical surges.
19. All spare field wires within each panel or enclosure shall be coiled, and each coil shall be labeled with the wire destination. Neatly arrange spare wire coils in the bottom of the enclosure.
20. Provide complete wiring diagram showing "as built" circuitry. Diagram shall be enclosed in transparent plastic and placed in easily accessible pocket built into panel door.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in conformance with NEC.

B. Unless otherwise noted, install indoor free standing and floor mounted panels on 4-inch grout pad. Lay grout after panel sills have been securely fastened down. Extend pad 4 inches beyond outside dimensions of base, all sides, solid, and face-to-face.

C. Unless otherwise noted, install outdoor free standing and floor mounted panels and sun shields on a reinforced concrete pedestal:
   1. Minimum Thickness: 8 inches with No. 4 steel reinforcing bars at 12 inches on centers, each way.
   2. Minimum Size: 12 inches larger than outer dimensions of base, each side.
   3. Provide excavation and backfill work in conformance with Section 02505, Pipe Embedment and Backfill Materials.
   4. Provide concrete work in conformance with Division 3, Concrete.

D. Unless otherwise noted, install all frame mounted indoor and outdoor panels and sun shields using strut style structural support framing system members, plates and fasteners as specified in Section 16070, Supporting Devices. Frame bases shall be installed on a minimum one inch thick non-shrink grout pad with edges sloped away from the base plate.

E. Install wall mounted enclosures and control panels and sun shields using strut style support channels securely anchored to wall surface to provide offset mounting for air circulation behind panel. Do not install wall mounted panels directly on wall surfaces. Comply with requirements of Section 16070, Supporting Systems, for support framing system materials and methods.

F. Install anchor bolts and anchor in accordance with Section 05051, Anchors, Bolts, Toggle Bolts, and Concrete Inserts.

G. Install and interconnect all equipment, devices, electrical hardware, instrumentation and controls, and process controller components into and out of and among the enclosures as indicated on the Drawings.

3.2 TESTING AND ADJUSTMENT

A. Perform system testing and make any adjustments necessary in accordance with this Section and with the Specifications of Section 13403, Plant Monitoring and Control System Start-up, and Field Testing.

B. Perform power supply, voltage adjustments to tolerances required by the appurtenant equipment.

+ + END OF SECTION + +

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SECTION 13440

PANEL MOUNTED INSTRUMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope of Work:
   1. CONTRACTOR shall furnish, install, test, and place into satisfactory operation the control panels, enclosures, and panel devices as shown on the Drawings and specified herein.
   2. Operational and functional requirements for the various panels are shown in control schematics, pneumatic diagrams, and/or functional instrumentation diagrams on the Instrumentation (I) drawings and Electrical (E) drawings.
   3. The Drawings and Specifications illustrate and specify functional and general construction requirements of the panel components and do not necessarily show or specify all components, wiring, piping, and accessories required to make a completely integrated system. CONTRACTOR shall provide all piping, wiring, accessories, and labor required for a complete, workable, and integrated system.

1.2 QUALITY ASSURANCE

A. Standards, Codes and Regulations:
   1. Construction of panels and the installation and interconnection of all equipment and devices mounted within shall comply with applicable provisions of the following standards, codes, and regulations:
      a. National Electrical Code (NEC).
      b. National Electrical Manufacturer's Association (NEMA) Standards.
      c. Institute of Electrical and Electronics Engineers, Inc (IEEE).
      d. Local and State Building Code.
      e. Operational Safety and Health Administration (OSHA) Regulations.
      f. American Society for Testing and Materials (ASTM).
      g. Where any conflict arises between codes or standards, the more stringent requirement shall apply.
   2. All electrical materials and equipment shall be new and shall bear the label of the Underwriters Laboratory (UL), Inc., Factory Mutual (FM) or equivalent where standards have been established and label service regularly applies. Acceptable Manufacturers:
   3. Furnish panel instruments and devices by the named manufacturers or equal equipment by other manufacturers.
   4. The named manufacturers have been specified to establish the standard of quality and performance of the equipment to be supplied.
   5. Obtain all instruments or devices of a given type from the same manufacturer.

B. General Design Requirements:

1. Comply with the requirements of Section 13401, Instrumentation and Control System General Requirements.

C. Factory Assembly and Testing:
   1. Comply with the requirements of Section 13402, Instrumentation and Control System Factory Testing.

1.3 SUBMITTALS

A. Comply with the requirements of Section 13401, Instrumentation and Control System General Requirements.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements of Section 13401, Instrumentation and Control System General Requirements.

PART 2 - PRODUCTS

2.1 GENERAL CONSTRUCTION REQUIREMENTS

A. Comply with the requirements of Section 13401, Instrumentation and Control System General Requirements.

2.2 IDENTIFICATION

A. Tag all panel mounted instruments in accordance with Section 13420, Primary Sensors and Field Instruments, Paragraph 2.0.1.

2.3 CONTROL RELAY

A. Type: General purpose, plug-in type rated for continuous duty.

B. Performance Requirements:
   1. UL recognized.
   2. Contact Configuration: Number and arrangement as required to perform the intended functions, plus a minimum of one spare SPDT contact per relay function.
   3. Coil Voltage: 24 VDC or 120 VAC as required.

C. Construction Features:
   1. Contact Material and Rating:
      a. General Use: Silver or silver cadmium oxide contacts rated for 10 amps minimum at 120 VAC.
      b. Low Power Switching: Fine silver, gold flashed contacts specifically designed for low power switching, rated for 2 amps minimum at 30 VDC.

2. Mounting: Pin or blade mount in sockets for subpanel mounting on DIN rail. Sockets shall have screw terminals for wiring connections which shall accept a minimum of two #14 AWG wires.

D. Accessories:
   1. Clear plastic dust cover.
   2. Indicator light.

E. Manufacturer and Model:
   1. Potter & Brumfield, KRPA or R10-T.
   2. Allen Bradley, 700 Series.
   3. Or equal.

2.4 TIME DELAY RELAY

A. Type: Dial adjustable, plug-in type time delay relay providing delay-on-make, delay-on-break or interval operation.

B. Construction Features:
   1. MOS digital circuit with transformer coupled power.
   2. Switch selectable ranges as follows:
      a. One second.
      b. Ten seconds.
      c. One minute.
      d. Ten minutes.
      e. One hour.
      f. Ten hours.
   3. Minimum Setting: Three percent of range, except 50 ms for one-second range.
   4. Setting Knob Accuracy: Ten percent.
   5. Contacts:
      a. Type: DPDT.
      b. Rating: 5 A resistive at 120 VAC, 5 A at 24 VDC.
   6. Housing: Plug-in design with dust and moisture resistant molded plastic case.
   7. Power Input: 120 VAC or 24 VDC as required.
   8. Operating Temperature: 0 to 55 degrees C.
   9. Unit shall have LED to show timing status.
   10. Relays to be UL recognized.

C. Manufacturer and Model:
   1. Automatic Timing and Controls Company, Series 328D.
   2. IDEC, Series GE1A.
   3. Or equal.

2.5 PUSHBUTTONS, SELECTOR SWITCHES AND INDICATING LIGHTS

A. Type: Full size, heavy duty, oiltight, round type operators with modular contacts and NEMA rating equal to that of the enclosure on which devices are installed.

B. Performance Requirements:
   1. Selector switches, pushbuttons and indicating lights shall be supplied by one manufacturer and be of the same series or general model type.
   2. Common, remote push-to-test circuitry shall be provided for each control panel to simultaneously test all indicating lights on the panel using a single pushbutton when there are 10 or more lights on the panel. Control panels with less than 10 lights shall utilize individual push-to-test lights and control circuitry.
   3. Provide individual legend plates for indication of switch, pushbutton, and light functions (e.g. Open, Closed, Hand-Off-Auto). Legend plates shall conform to the requirements of Paragraph 2.2. above.
   4. All components shall be flush mounted on front of panel, unless otherwise noted. Construction Features:
   5. Selector Switches:
      a. Two, three and four position as required.
      b. Maintained or momentary contacts; number and arrangement as required to perform intended functions specified but not less than one double pole, double throw, double break contact per switch. Contact rating shall be compatible with ac or dc throughput current of devices simultaneously operated by the switch contacts but not less than 10 amperes resistive at 120 volts ac or dc continuous.
      c. Black knob operator.
   6. Pushbuttons:
      a. Maintained or momentary as required and as shown on the Drawings.
      b. Contacts shall comply with requirements specified for selector switches above.
      c. Provide extended head pushbutton for all stop functions and flush head pushbuttons for all other functions.
      d. Colors:
         1) Green - Start, Open.
         2) Red - Stop, Close.
         3) Black - Status.
   7. Indicating Lights:
      a. LED lamp type
      b. Remote common test or integral push-to-test as specified above.
      c. Lens Colors:
         1) Green – Running, Open.
         2) Red - Stopped, Closed.
         3) Amber - Malfunction.
         4) White - Status.
         5) Blue - Power On.

C. Product and Manufacturers:
   1. Allen-Bradley Types 800T and 800H.
   2. Or equal.

2.6 POWER SUPPLY

A. Function: Provide DC power for two wire current loops. Provide a separate dedicated power supply for each current loop.

B. Type: A single output, regulated, plug-in type 24 Vdc power supply.

C. Performance Requirements:
   1. Temperature: Operational from -10 to 65 degrees C.
   2. Output: 24 Vdc, 200 mA.
   3. Power Requirements: 120 VAC, 60-Hz, single phase.
   4. Regulation: ±0.5 percent.
   5. Ripple: 0.5 mV RMS.
   6. Protection: Overvoltage protection.
   7. Approval: U.L. recognized.

D. Construction Features:
   1. Mounting: Power supply to snap onto DIN rail.

E. Manufacturer and Model:
   1. Phoenix Contact MINI-PS-100-240AC/24DC/1.
   2. Sola SDP06-24-100T
   3. Or equal.

2.7 ELAPSED TIME METER (HOUR METER)

A. General: Unit shall be a powered, non-resettable time indicator, with easy to read analog figures.

B. Required Features:
   1. Power: 120 VAC.
   2. Accuracy: Within one percent.
   3. Capacity: Up to 99,999.9 hours (automatic recycle at zero); one-tenth hour resolution.
   4. Operating Temperature: -40 to +68 degrees C.
   5. Sealed against dirt and moisture.
   6. Tamperproof.
   7. Shock resistant.
   8. Panel mountable.
   9. Nameplate above display shall read "TOTAL HOURS".

C. Manufacturer and Model:
   1. Dynapar/Veeder-Root, 7795 Series.
   2. Cutler-Hammer, E42DIR Series.
   3. Or equal.

2.8 DIGITAL INDICATORS

A. Type: Digital panel meter, utilizing current to convert analog signal to LED readout.

B. Required Construction Features:
   1. Accept 1-5V dc or 4-20 mA dc input signal.
   2. Accuracy: 0.05 percent 2 counts.
   3. Zero and span adjustment/scaling.
   4. Display: 4 digits (9,999) minimum LED display.
   5. Mounting: Housing designed for front panel mounting. Provide NEMA 4X rated front when required.
   6. Power Supply: 120 VAC, 50/60 Hz.
   7. Resistors: Provide 1 percent precision resistors for 4-20 mA dc input signal conversion where required.
   8. Display Segment Size: 0.56 inches.
   9. Display Color: Red.
   10. Relays: Adjustable alarm trip with 2 SPDT relay contacts rated at 2 amps at 250VAC.
   11. Loop Power: 24 VDC loop power for two-wire instruments.
   12. Range and Scale: As specified in Instrument Schedule for associated signal transmitter.

C. Manufacturer and Model:
   1. Precision Digital, Model PD765.
   2. Or equal.

2.9 STROBE LIGHT

A. General: Strobe light shall be a pulsating, illuminating type. The light shall provide a visual warning in the area where a potential hazard may occur.

B. Required Features
   1. Strobe Light: Rotating 360 degrees;300 effective candlepower,80 flashes per minute.
   2. Lens Color: Amber.
   3. Enclosure Rating: NEMA4X or NEMA7 in classified areas.
   4. Power: 120VAC.

C. Product and Manufactures:
   1. Federal Signal.
   2. Or equal.

2.10 SURGE PROTECTION

A. Power Surge Protection:
   1. A surge protection device shall be installed on the power feed to each panel supplied by the system supplier. The power surge protection device shall be rated for 120 VAC, Single Phase.
   2. The power surge protection device shall have the following features:
      a. Response Time: Less than 5 nanoseconds.

b. Maximum Surge Current: 40,000 Amps/phase.
c. Maximum Energy Absorption (2 ms): 360 Joules/phase.
d. Initial Clamping Voltage: 240 Volts Nominal.
e. Clamp Voltage at 300A: 395 Volts Nominal.
f. Maximum Allowable Voltage (L-N): 150 Vrms, 50-60 Hz.
g. Maximum Allowable Voltage (L-L): 275 Vrms, 50-60 Hz.
h. Failure Mode: Failsafe (short) and Fused.
i. Failure Indication: LED Indicator.
j. Surge Life at 10,000A: Greater than 50 Occurrences.

3. Power surge suppressors at all sites shall be of the same manufacturer and model number.
4. Manufacturer and Model Number:
   a. EDCO, EMC-240B.
   b. Or equal.

B. Signal Surge Protection:
1. A signal surge protection device shall be installed on all signal loops that run outdoors or between buildings.
2. The signal surge protection device shall have the following features:
   a. Maximum Signal Voltage: 28 V max.
   b. DC Clamping Level (L-G): 36V ±10 percent.
   c. DC Clamping Level (L-L): 72V ±10 percent.
   d. Maximum Let Through Voltage (L-G, 10x700 s): 44V at 400A.
   e. Maximum Let Through Voltage (L-L, 10x700 s): 90V at 400A.
   f. Series Resistance: 8Ω.
   g. Capacitance, zero volts bias (L-G): 1200 pf.
   h. Capacitance, zero volts bias (L-L): 600 pf.
   i. Number of Occurrences: 400 at 500A.
   j. Enclosure: Encapsulates in Stainless Steel Pipe Nipples.
3. Signal surge suppressors at all sites shall be of the same manufacturer and model number.
4. Manufacturer and Model Number:
   a. EDCO, SS-64.
   b. Or equal.

2.11 UNINTERRUPTIBLE POWER SYSTEM

A. Uninterruptible Power System (UPS) shall be furnished to provide a reliable source of uninterruptible power with no break in AC output power during a complete or partial interruption of incoming line power. UPS shall include audio/visual alarms. UPS shall be UL listed.

B. Rating: 120 VAC, 60 Hz, 1.4KVA/1.0KW minimum to provide uninterrupted conditioned power, fully loaded conditions for 20 minutes.

C. Description: On line dual track power conditioner and true (0 ms transfer time) uninterruptible power supply providing isolation, line regulation and conditioning, using sealed 48 VDC maintenance free batteries and switch mode power supply for uninterrupted power with 0.5 to 0.7 power factor and 2.7 to 3.5 crest factor.

D. Required Features:
   1. Lighting and Surge Protection: Inherent 2000: One spike attenuation.
   2. Regulation: One to three percent load regulation with less than 2pF effective coupling capacitance for line to load.
   3. Output Waveform: Computer grade sine wave with three percent maximum single harmonic and five percent maximum total harmonic distortion.
   4. Output Frequency: 60 Hz ±0.5 Hz.
   5. Operating Temperature: 1 to 40 degrees C.
   6. Relative Humidity: Five to 90 percent non-condensing.
   7. Computer Interface: RS232 port for display of 22 meter functions and 15 alarm functions.
   8. Input Protection: Independent battery charger fuse and DC fuses.
   9. Output Protection: Inherently current limited ferro-resonant transformer.
   10. Battery Charger: Two-step charger, 8 A and 2 A.
   11. AC Input: 120 VAC, 60Hz, single phase, +15 percent, -20 percent.
   12. AC Output: 120 VAC, 60Hz, single phase, +3 percent, -3 percent.

E. Manufacturer and Model:
   1. American Power Conversion Corp. (APC) SMART UPS.
   2. Or equal.

2.12 ALARM HORNS

A. Performance Requirements:
   1. Sound Rating: 103 dB minimum at 10 feet.

B. Construction Features:
   1. Volume Control: Adjustable.
   2. Mounting: Semi-flush mounted.
   3. Housing: NEMA 4X, corrosion resistant finish.
   4. Diaphragm: Stainless steel.
   5. Power: 120 VAC, 60 Hz.
   6. U.L. approved.

C. Manufacturer and Model:
   1. Edwards Signaling Products, Model 870P, Series Adapta Horne.
   2. Federal Signal Model 350
   3. Or equal.

2.13 SPARE REPLACEMENT UNITS AND PARTS

A. Spare replacement instruments and components shall be provided for the panel mounted devices as follows:
   1. 20% spare bulbs for each type of bulb used in the system.
   2. 20% spare fuses for each type of fuse used in the system.
   3. One spare 24 VDC power supply used in the system.
   4. Five spare relays used in the system.
   5. Two spare intrinsically safe relays used in the system.
   6. Two spare surge protection devices used in the system.

B. All spare parts shall be individually packaged for protection against impact, moisture and dirt. Each package shall be clearly labeled as to its contents with a description and part number.

C. All spare parts shall become the property of the Owner. Contractor shall maintain the spare parts inventory as listed above, and replace, at no additional cost, all spare parts consumed during the one-year warranty period.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in conformance with NEC.

B. Install and interconnect all equipment, devices, electrical hardware, instrumentation and controls, and process controller components into and out of and among the enclosures as indicated on the Drawings.

+ + END OF SECTION + +

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SECTION 13451

PROGRAMMABLE CONTROLLER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. CONTRACTOR shall furnish all labor, materials, and components, and shall provide all design, assembly, testing, and start-up services required to provide a complete and operational programmable controller (PLC) system as specified and shown on the Drawings. The system includes, but is not necessarily limited to the following:
   1. PLC processors.
   2. PLC Input/Output (I/O) modules, chassis, and power supplies.
   3. Communications networks.
   4. PLC system detailed design, assembly, installation, testing, and start-up services.

B. The PLC system configuration shall be as shown on the Drawings and specified herein. The PLC system configuration was developed using Allen Bradley ControlLogix 1756 Series, input/output modules as the basis of design. Some variations in the configuration will be considered provided the physical and functional constraints as intended for the various system components are met.

C. The Process and Instrumentation Diagrams (P&ID's) and the specifications of this Section and the other 13400 Sections generally illustrate and describe the overall PLC System requirements.

D. All equipment shall be constructed specifically for the demanding requirements of real-time process management and control on a continuous basis for use in a municipal wastewater treatment plant.

E. The DeviceNet Network requirement and the specification generally illustrate and described in Section 13453.

1.2 SUBMITTALS

A. Comply with the requirements of Section 13401, Plant Monitoring and Control System General Requirements.

B. Copies of the communication tower and foundation drawings and calculations bearing the seal and signature of a professional engineer registered in the State of Ohio. Engineer will accept design calculations for information purposes.

1.3 QUALITY ASSURANCE

A. Comply with the requirements of Section 13401, Plant Monitoring and Control System General Requirements.

1.4 EQUIPMENT DELIVERY, HANDLING, AND STORAGE.

A. Comply with the requirements of Section 13401, Plant Monitoring and Control System General Requirements.

PART 2 - PRODUCTS

2.1 PLC SYSTEM GENERAL REQUIREMENTS

A. All materials and equipment furnished shall be new, free from defects, and of first quality, produced by manufacturers who have been regularly engaged in the manufacture of these products.

B. All materials furnished under this Contract shall be determined safe by either Underwriters Laboratories, Inc., or Factory Mutual and all material shall be labeled, certified, or listed by the testing agency.

C. Provide PLC processors, communication modules, local and remote I/O components, and other hardware and system components required for a complete functioning PLC System to meet the intent of the configuration drawing and as listed in the PLC System I/O Schedule at the end of this section. The PLC shall be configured to perform the functions shown on the Contract Drawings and specified herein.

D. The PLC shall be designed, constructed and tested in conformance to NEMA Standard ICS 3-304 for programmable controllers, and shall be suitable for use under the following environmental conditions:
   1. Operating Temperature: 32 to 140 degrees F.
   2. Relative Humidity: 5 to 95 percent non-condensing.
   3. Shock: 30 G peak acceleration for 11ms duration.
   4. Vibration: 10 to 500 Hz, 2.0g maximum peak acceleration.

E. The PLC shall be capable of being programmed in both an off-line (program) mode and an on-line (run) mode by means of a portable personal computer based laptop programming unit connected to the PLC processor installed in the system I/O chassis and/or connected to the processor via the PLC System Ethernet Communication Link at a remote location. On-line data and program logic changes shall not necessitate halting the processor.

F. The PLC shall be a complete system of modular design consisting of the following major components:
   1. PLC (CPU) processor modules.

2. Discrete and Analog I/O modules of the types and quantities described in the Input/Output list at the end of this Section.
3. Chassis for housing, distributing power to, and providing digital interfacing of the CPU and I/O modules.
4. 120 VAC system power supply for providing DC operating power to the chassis, processor, and I/O modules.
5. Communications to distributed I/O racks and to the HMI and to other networks.
6. Miscellaneous communications hardware and wiring components necessary for a complete functioning PLC system.

G. The chassis design shall be suitable for subpanel mounting inside control panels. All system modules shall be designed for easy removal from and replacement in the chassis. The PLC shall be designed to allow removal and insertion of any module under power without disruption to the system. All discrete and analog I/O modules shall be designed to permit module removal and re-installation without disturbing or disconnecting any field wiring terminations.

H. The I/O chassis design shall provide any card, any slot, plug-in packaging, with locking bars and/or screws to hold the I/O modules in place. Electronic keying shall be used to prevent insertion of an I/O module into the wrong chassis slot, once the slot assignments and module layouts are finalized.

I. The PLC editor shall be IEC-61131 compliant.

2.2 APPLICATION PROCESSOR (CPU)

A. Type: Microprocessor based, industrial, single slot CPU with minimum I/O capacity of 2048 points, any mix of inputs and outputs.

B. Processor memory: 2 Megabyte user memory.

C. Non-Volatile Memory: Module shall contain Compact Flash slot for memory backup. The memory shall maintain data for a minimum of one year with no power applied to the processor. Provide one 64 MB Compact Flash card for each CPU.

D. Program Scan Rate: less than 0.1 ms typical.

E. Installation Location: Any slot in the I/O chassis to the right of the communication cards (as required by the manufacturer).

F. Diagnostics:
1. Standard, self-diagnostic routines shall be provided to determine proper hardware and software operation.
2. Diagnostic LED's shall be provided on the processor front panel to indicate the following:
   a. Processor running.

b. Processor fault.
c. Battery low.
d. Forced I/O.
e. Communications active.
f. Communications error.

G. System Communications: The PLC shall be equipped with a built-in serial port for connection to the programming unit. Provide Ethernet Interface modules for communication as shown on the configuration drawing, and specified in Paragraph 2.3 below.

H. Instruction Set:
1. The PLC shall be equipped with the following instructions as a minimum:
a. Ladder and function block programming.
b. Ladder-logic or relay-type logic functions: Normally open contacts, normally closed contacts, and output coils.
c. Timers: On delay, off delay, and retentive.
d. Counters: Up, down.
e. Math functions including integer and floating point: Add, subtract, multiply, divide, and square root.
f. Data transfer instructions: Bit, word, and file.
g. Logical instructions: AND, NOT, OR, XOR.
h. Compare instructions: Equal to, greater than, less than.
i. Control: Proportional - Integral - Derivative control instruction.
j. Advanced instruction set including file handling, sequencer, diagnostic, shift register, immediate I/O, and program control instructions.
2. The PLC shall support branching functions to allow any combination of series or parallel instructions.
3. The PLC shall support the use of subroutines where appropriate.

I. Clock: Battery-backed clock with a typical variation of ± 20 seconds per month.

J. Manufacturer and Model:
1. Allen Bradley 1756 Series Logix 5561 processor, (with 64MB industrial Compact flash card).

2.3 COMMUNICATION INTERFACE MODULES

A. The PLC system shall include Ethernet and DeviceNet modules as required for system communications. The Ethernet modules shall enable the PLC processor to communicate with other PLCs and HMI at a minimum of 10Mb/sec.

B. Provide all repeater adapters, fiber repeater, terminator plugs/resistors, and other required communications hardware for complete workable Ethernet and DeviceNet communications systems.

C. Manufacturer and Model:
   1. Allen Bradley ControlLogix Compatible Modules:
      a. Ethernet Communication Interface: Allen Bradley Ethernet/IP Bridge Module (1756-ENBT).
      b. DeviceNet Communications Interface: Allen Bradley DeviceNet Bridge Module (1756-DNB).
      c. ControlNet Communication Interface: Allen Bradley ControlNet Bridge Module (1756-CNB).

2.4 POWER SUPPLY

A. Each PLC processor chassis and remote I/O chassis shall include a separate power supply. The power supply shall be mounted alongside the I/O chassis.

B. Input Voltage: 120 VAC, 60-Hz.

C. Output Current: Coordinate Power Supply output with equipment provided. As a minimum, provide 13 amp at 5 VDC.

D. Provide all cabling as required.

E. Manufacturer and Model:
   1. Allen Bradley 1756 -PA75.

2.5 I/O CHASSIS

A. Type: I/O chassis designed to house the PLC processor, distributed I/O communication module, and the I/O modules. The chassis shall be subpanel mounted.

B. I/O Slots Required: Provide local and remote I/O chassis with the number of slots as required to house all active modules plus an additional 20 percent spare rack space in each chassis. Arrange I/O as follows:
   1. Left most module group shall be digital input modules.
   2. Modules to the right of the digital input module group shall be digital output modules
   3. Right most module group shall be analog output modules
   4. Modules to the left of the analog output module group shall be analog input modules.
   5. Spares (with blank filler plate) shall be located in the center.

C. I/O points shall be arranged (per group of modules) in alphabetical order with the 25% spare I/O at the end of each module.

D. Manufacturer and Model:
   1. Allen Bradley 1756-A13 Series ControlLogix Chassis

2.6 PLC SYSTEM I/O MODULES

A. Available Types: The types of I/O modules available for use with the PLC system shall be as specified and as identified in the input/output list at the end of this section.
   1. Sixteen point individually isolated discrete input modules which accept an input of 115 VAC, 60-Hz. The discrete input modules shall be Allen Bradley Model 1756-IA16I.
   2. Sixteen point isolated output modules. Isolated outputs shall have a current capacity of 2 amps at 115 VAC. The isolated output modules shall be Allen Bradley Model 1756-OA16I.
   3. Six point isolated analog input modules (12 bit minimum resolution) which accept an input of 4-20 mA DC. The analog input modules shall be Allen Bradley Model 1756-IF6I.
   4. Six point isolated analog output modules (12 bit minimum resolution) which produce an output of 4-20 mA DC. Analog output modules shall allow selectable output response to faults of minimum, maximum, or last output value. The analog output modules shall be Allen Bradley Model 1756-OF6CI.

B. Required Features: The I/O modules and system hardware supplied shall incorporate the following design and construction features and comply with the following requirements:
   1. Noise immunity and filtering.
   2. IEEE surge-withstand rating to IEEE 472.
   3. Optical isolation for all inputs and outputs to provide controller logic protection.
   4. Any card, any slot, plug-in packaging, with locking bars and/or screws to hold I/O modules in place.
   5. 300 volt, screw type, I/O wiring terminal arms sized to accommodate a minimum of two #14 AWG wires per terminal. Wiring design shall allow I/O module removal and replacement without disturbing I/O wiring connections.
   6. Front-of-module LED Status indicators for each individual input and output point to indicate when power is applied at I/O terminals.
   7. Where required and recommended by the manufacturer, external transient suppressors shall be provided for installation across the output loads.
   8. Scaling to engineering units for analog modules.
   9. Provide required connectors with each I/O module.

   For each PLC I/O rack, provide installed I/O capacity of the types and quantities as identified in the Input/Output Schedule, plus an additional 25% spare capacity for each type of I/O. All I/O, including future and spare, shall be wired to fused terminal blocks prior to interconnection with other devices. Fused terminal blocks shall have blown fuse indication.

2.7 WIRING ACCESSORIES

A. Provide wiring accessories, including but not limited to, connectors, taps, terminator lugs, and screw clamp blocks as recommended by the manufacturer for a complete PLC system installation.

2.8 NOT USED

2.9 INPUT/OUTPUT SCHEDULE

A. An Input/Output (I/O) schedule for the programmable controller system is included at the end of this section. Contractor shall provide the input/output capacity necessary to facilitate the system functional requirements as specified and shown on the Drawings.

2.10 SPARE PARTS AND EXPENDABLE MATERIALS

A. The following spare parts and expendable materials shall be provided as a minimum, for the PLC System:
   1. One of each type I/O module (including associated wiring terminal block)for each ten or fraction thereof used in the system.
   2. One of each type of the following modules used in the system:
      a. Processor modules.
      b. Communications modules.
      c. Any other type of special function modules.
      d. 64 MB CompactFlash card.
   3. One replacement power supply for each type used in the system.
   4. One replacement I/O chassis for each size used in the system.
   5. Ten percent of total quantity of each type of fuse used in the system.
   6. Ten percent of total quantity of each type of lamp used in the system.
   7. One Ethernet switch of each type used in the system
   8. Two fiber optic media converter of each type used in the system.

B. All spare parts shall be individually packaged for protection against impact, moisture, and dirt. Each package shall be clearly labeled as to its contents with a description and part number.

   All spare parts shall become the property of the OWNER. The CONTRACTOR shall maintain the spare parts inventory as listed above, and replace, at no additional cost, all spare parts consumed during the one-year warranty period.

2.11 NETWORKING EQUIPMENT:

A. General:
   1. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.
   2. Provide all necessary items for installation, including mounting brackets, interconnecting cables, hardware and appurtenances.

B. Managed Ethernet Switch:
   1. Minimum of 8 copper RJ-45 ports, and 2 fiber optic (mini-GBIC) ports. Provide switch(es) with number of ports required plus 20% spare (copper only).
   2. One DB-9 RS-232 interface port.
   3. Jumbo Frames: 10K
   4. MAC Address Table: 8K
   5. Switching Method: Store and Forward.
   6. Security: IEEE 802.1x: - RADIUS Authentication, MD5 Encryption Access
   7. One 1 IEC320 power cord.
   8. One expansion cable.
   9. Rack mount kit
   10. Per Unit LEDs: Power status, collision, over temperature.
   11. Per Port LEDs: Packet reception, partition, link status.
   12. LCD unit ID indicator.
   13. Quantity: As shown on Drawings.
   14. Fast Ethernet hub shall comply with the following standards:
      a. IEEE 802.3u. 100Base-T compliant.
      b. IEEE 802.3x Flow Control, 803.3ad LACP, 802.1d STP 802.1 Q/p VLAN, 802.1 Rapid STP, 802.1s Multiple STP, 802.1x Port Access Authentication.
      c. ISO 8802/3.
   16. Products and Manufacturers: Provide one of the following:
      a. SRW Series managed switch as manufactured by Cisco.
      b. Or equal.

B. Fiber Optic Media Converters
   1. Provide device to convert Ethernet communication between CAT6 copper and Multimode fiber optic cable.
   2. Manufacture: Provide product of the following:
      a. Cisco.

PART 3 - EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. General:
   1. Install all equipment and components in accordance with the Drawings, approved Shop Drawings, and installation instructions furnished by the manufacturer.
   2. Do not begin installation of system hardware and panels until building construction is completed and major equipment has been installed.
   3. Maintain areas where instruments, control panels, and enclosures are being or have been installed, dust free and within the environmental conditions specified for the equipment.

4. Inspect each instrument, panel and other items for damage and defects before installation. Replace deficient items.
5. The PLC and I/O racks shall be installed such that all LED indicators and switches are readily visible with the panel door open and such that repair and/or replacement of any PLC component can be accomplished without disconnecting any wiring or removing any other components.
6. Comply with the other specific installation, start-up, and testing requirements as specified in Section 13401, Plant Monitoring and Control System General Requirements, Section 13402, Plant Monitoring and Control System Factory Testing, and Section 13403, Plant Monitoring and Control System Start-up, and Field Testing, Section 13453, DeviceNet.

+ + END OF SECTION ++

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TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC - 1 (SLUDGE BLDG.) PARTIAL INPUT / OUTPUT SCHEDULE							
PLC PANEL	**MOD**	**RACK**	**SLOT**	**POINT**	**Description/Location**	**Input from/Output to**	**Calibrated Range**
PLC-1	DI	0	**	**	~~Spare~~ FTWR Valve Actuator in Remote	Valve Actuator	--
PLC-1	DI	0	**	**	~~Spare~~ FTWR Valve Actuator Fault	Valve Actuator	--
PLC-1	DI	0	**	**	~~Spare~~ FTWR Vault Flood	LSH-0199	--
PLC-1	AI	0	**	**	~~Spare~~ FTWR Flow Indicator	FIT-G0200	0 - 1000 GPM
PLC-1	AI	0	**	**	~~Spare~~ FTWR Valve Actuator Position Indicator	Valve Actuator	0 - 100%
PLC-1	AO	0	**	0	FTWR Valve Actuator Position Setpoint	Valve Actuator	0 - 100%
PLC-1	AO	0	**	1	Spare		
PLC-1	AO	0	**	2	Spare		
PLC-1	AO	0	**	3	Spare		
PLC-1	AO	0	**	4	Spare		
PLC-1	AO	0	**	5	Spare		

** Note: Contractor shall field verify exsting PLC to locate spare points and spare slots.

MAIN PLC PARTIAL INPUT / OUTPUT SCHEDULE							
PLC PANEL	**MOD**	**RACK**	**SLOT**	**POINT**	**Description/Location**	**Input from/Output to**	**Calibrated Range**
MAIN PLC	DI	0	5	9	~~Spare~~ High Service Pump No. 1 Fault	MCC	--
MAIN PLC	DI	0	5	10	~~Spare~~ High Service Pump No. 2 Fault	MCC	--
MAIN PLC	DI	0	5	11	~~Spare~~ High Service Pump No. 3 Fault	MCC	--
MAIN PLC	DI	0	**	**	~~Spare~~ Filtered Water Sample Pump in Remote	MCC	--
MAIN PLC	DI	0	**	**	~~Spare~~ Filtered Water Sample Pump Run Status	MCC	--
MAIN PLC	DI	0	**	**	~~Spare~~ Filtered Water Sample Pump Overload	MCC	--
MAIN PLC	DO	0	**	**	~~Spare~~ Filtered Water Sample Pump Start/Stop	MCC	--

** Note: Contractor shall field verify exsting PLC to locate spare points and spare slots.

GAC - PLC (RACK 0) INPUT / OUTPUT SCHEDULE							
PLC PANEL	**MOD**	**RACK**	**SLOT**	**POINT**	**Description/Location**	**Input from/Output to**	**Calibrated Range**
GAC-PLC	CPU	0	0	--	PLC Processor		
GAC-PLC	ENET	0	1	--	Ethernet/IP Communication Bridge		
GAC-PLC	CNET	0	2	--	ControlNet Bridge		
GAC-PLC	DNET	0	3	--	DeviceNet Communication Bridge - Network 1		
GAC-PLC	DNET	0	4	--	DeviceNet Communication Bridge - Network 2		
GAC-PLC	DNET	0	5	--	DeviceNet Communication Bridge - Network 3		
GAC-PLC	DNET	0	6	--	DeviceNet Communication Bridge - Network 4		
GAC-PLC	DI	0	7	0	GAC Backwash Supply Pump E-Stop	LCS	--
GAC-PLC	DI	0	7	1	GAC Backwash Supply Pump Run Status	MCC	--
GAC-PLC	DI	0	7	2	GAC Backwash Supply Pump Motor Temperature High	MCC	--
GAC-PLC	DI	0	7	3	GAC Backwash Supply Pump in Remote	MCC	--
GAC-PLC	DI	0	7	4	GAC Backwash Supply Pump Overload	MCC	--
GAC-PLC	DI	0	7	5	UV Reactor No. 2 Inlet Valve Actuator Opened Indication	Valve Actuator	--

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
GAC-PLC	DI	0	7	6	UV Reactor No. 2 Outlet Valve Actuator Opened Indication	Valve Actuator	--
GAC-PLC	DI	0	7	7	Spare Point		--
GAC-PLC	DI	0	7	8	Spare Point		--
GAC-PLC	DI	0	7	9	Spare Point		--
GAC-PLC	DI	0	7	10	UV Reactor No. 1 Inlet Valve Actuator Closed Indication	Valve Actuator	--
GAC-PLC	DI	0	7	11	UV Reactor No. 1 Inlet Valve Actuator in Remote	Valve Actuator	--
GAC-PLC	DI	0	7	12	Spare Point		
GAC-PLC	DI	0	7	13	Spare Point		
GAC-PLC	DI	0	7	14	Spare Point		
GAC-PLC	DI	0	7	15	Spare Point		
GAC-PLC	DI	0	8	0	UV Reactor No. 1 Inlet Valve Actuator Fault	Valve Actuator	--
GAC-PLC	DI	0	8	1	UV Reactor No. 1 Inlet Valve Actuator Opened Indication	Valve Actuator	--
GAC-PLC	DI	0	8	2	UV Reactor No. 1 Outlet Valve Actuator Closed Indication	Valve Actuator	--
GAC-PLC	DI	0	8	3	UV Reactor No. 1 Outlet Valve Actuator in Remote	Valve Actuator	--
GAC-PLC	DI	0	8	4	UV Reactor No. 1 Outlet Valve Actuator Fault	Valve Actuator	--
GAC-PLC	DI	0	8	5	UV Reactor No. 1 Outlet Valve Actuator Opened Indication	Valve Actuator	--
GAC-PLC	DI	0	8	6	UV Reactor No. 2 Inlet Valve Actuator Closed Indication	Valve Actuator	--
GAC-PLC	DI	0	8	7	UV Reactor No. 2 Outlet Valve Actuator Closed Indication	Valve Actuator	--
GAC-PLC	DI	0	8	8	UV Reactor No. 2 Inlet Valve Actuator in Remote	Valve Actuator	--
GAC-PLC	DI	0	8	9	UV Reactor No. 2 Outlet Valve Actuator in Remote	Valve Actuator	--
GAC-PLC	DI	0	8	10	UV Reactor No. 2 Inlet Valve Actuator Fault	Valve Actuator	--
GAC-PLC	DI	0	8	11	UV Reactor No. 2 Outlet Valve Actuator Fault	Valve Actuator	--
GAC-PLC	DI	0	8	12	Spare Point		
GAC-PLC	DI	0	8	13	Spare Point		
GAC-PLC	DI	0	8	14	Spare Point		
GAC-PLC	DI	0	8	15	Spare Point		
GAC-PLC		0	9	--	Spare Slot		
GAC-PLC		0	10	--	Spare Slot		
GAC-PLC	DO	0	11	0	GAC-PLC Fail	GAC-PLC	--
GAC-PLC	DO	0	11	1	GAC Backwash Supply Pump Start/Stop	GAC-PLC	--
GAC-PLC	DO	0	11	2	Spare Point		--
GAC-PLC	DO	0	11	3	UV Reactor No. 1 Inlet Valve Actuator Close	Valve Actuator	--
GAC-PLC	DO	0	11	4	UV Reactor No. 1 Inlet Valve Actuator Open	Valve Actuator	--
GAC-PLC	DO	0	11	5	UV Reactor No. 1 Outlet Valve Actuator Close	Valve Actuator	--
GAC-PLC	DO	0	11	6	UV Reactor No. 1 Outlet Valve Actuator Open	Valve Actuator	--
GAC-PLC	DO	0	11	7	UV Reactor No. 2 Inlet Valve Actuator Close	Valve Actuator	--
GAC-PLC	DO	0	11	8	UV Reactor No. 2 Inlet Valve Actuator Open	Valve Actuator	--
GAC-PLC	DO	0	11	9	UV Reactor No. 2 Outlet Valve Actuator Close	Valve Actuator	--
GAC-PLC	DO	0	11	10	UV Reactor No. 2 Outlet Valve Actuator Open	Valve Actuator	--
GAC-PLC	DO	0	11	11	Spare Point		

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
GAC-PLC	DO	0	11	12	Spare Point		
GAC-PLC	DO	0	11	13	Spare Point		
GAC-PLC	DO	0	11	14	Spare Point		
GAC-PLC	DO	0	11	15	Spare Point		
GAC-PLC	Slot Filler	0	12	--	Spare Slot		

GAC - PLC (RACK 1) INPUT / OUTPUT SCHEDULE							
PLC PANEL	**MOD**	**RACK**	**SLOT**	**POINT**	**Description/Location**	**Input from/Output to**	**Calibrated Range**
GAC-PLC	CNET	1	0	--	ControlNet Communication Bridge		
GAC-PLC	Slot Filler	1	1	--	Spare Slot		
GAC-PLC	Slot Filler	1	2	--	Spare Slot		
GAC-PLC	Slot Filler	1	3	--	Spare Slot		
GAC-PLC	AI	1	4	0	Backwash Pump Discharge Flow Indicator	FIT-G0400	0 - 1500 GPM
GAC-PLC	AI	1	4	1	Backwash Pump Discharge Pressure Indicator	PIT-G0400	0 - 250 PSIG
GAC-PLC	AI	1	4	2	Secondary Backwash Flow Indicator	FIT-G0401	0 - 250 PSIG
GAC-PLC	AI	1	4	3	GAC Vessel 1N Influent Flow Indicator	FIT-G0511	0 - 700 GPM
GAC-PLC	AI	1	4	4	Spare Point		
GAC-PLC	AI	1	4	5	Spare Point		
GAC-PLC	AI	1	5	0	GAC Vessel 1N Pressure Differential Indicator	PDIT-G0511	0 - 125 PSIG
GAC-PLC	AI	1	5	1	GAC Vessel 1S Influent Flow Indicator	FIT-G0611	0 - 700 GPM
GAC-PLC	AI	1	5	2	GAC Vessel 1S Pressure Differential Indicator	PDIT-G0611	0 - 125 PSIG
GAC-PLC	AI	1	5	3	GAC Vessel 2N Influent Flow Indicator	FIT-G0521	0 - 700 GPM
GAC-PLC	AI	1	5	4	GAC Vessel 2N Pressure Differential Indicator	PDIT-G0521	0 - 125 PSIG
GAC-PLC	AI	1	5	5	Spare Point		
GAC-PLC	AI	1	6	0	GAC Vessel 2S Influent Flow Indicator	FIT-G0621	0 - 700 GPM
GAC-PLC	AI	1	6	1	GAC Vessel 2S Pressure Differential Indicator	PDIT-G0621	0 - 125 PSIG
GAC-PLC	AI	1	6	2	GAC Vessel 3N Influent Flow Indicator	FIT-G0531	0 - 700 GPM
GAC-PLC	AI	1	6	3	GAC Vessel 3N Pressure Differential Indicator	PDIT-G0531	0 - 125 PSIG
GAC-PLC	AI	1	6	4	Spare Point		
GAC-PLC	AI	1	6	5	Spare Point		
GAC-PLC	AI	1	7	0	GAC Vessel 3S Influent Flow Indicator	FIT-G0631	0 - 700 GPM
GAC-PLC	AI	1	7	1	GAC Vessel 3S Pressure Differential Indicator	PDIT-G0631	0 - 125 PSIG
GAC-PLC	AI	1	7	2	GAC Vessel 4N Influent Flow Indicator	FIT-G0541	0 - 700 GPM
GAC-PLC	AI	1	7	3	GAC Vessel 4N Pressure Differential Indicator	PDIT-G0541	0 - 125 PSIG
GAC-PLC	AI	1	7	4	Spare Point		
GAC-PLC	AI	1	7	5	Spare Point		
GAC-PLC	AI	1	8	0	GAC Vessel 4S Influent Flow Indicator	FIT-G0641	0 - 700 GPM
GAC-PLC	AI	1	8	1	GAC Vessel 4S Pressure Differential Indicator	PDIT-G0641	0 - 125 PSIG
GAC-PLC	AI	1	8	2	GTW Turbidity	AIT-0700	0 - 2 NTU
GAC-PLC	AI	1	8	3	GAC Vessel 5N Influent Flow Indicator	FIT-G0551	0 - 700 GPM

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
GAC-PLC	AI	1	8	4	Spare Point		
GAC-PLC	AI	1	8	5	Spare Point		
GAC-PLC	AI	1	9	0	GAC Vessel 5N Pressure Differential Indicator	PDIT-G0551	0 - 125 PSIG
GAC-PLC	AI	1	9	1	GAC Vessel 5S Influent Flow Indicator	FIT-G0651	0 -700 PSIG
GAC-PLC	AI	1	9	2	GAC Vessel 5S Pressure Differential Indicator	PDIT-G0651	0 - 125PSIG
GAC-PLC	AI	1	9	3	GAC Vessel 6N Influent Flow Indicator	FIT-G0561	0 -700 PSIG
GAC-PLC	AI	1	9	4	GAC Vessel 6N Pressure Differential Indicator	PDIT-G0561	0 - 125PSIG
GAC-PLC	AI	1	9	5	Spare Point		
GAC-PLC	AI	1	10	0	GAC Vessel 6S Influent Flow Indicator	FIT-G0661	0 - 700 GPM
GAC-PLC	AI	1	10	1	GAC Vessel 6S Pressure Differential Indicator	PDIT-G0661	0 - 125 PSIG
GAC-PLC	AI	1	10	2	GAC Vessel 7N Influent Flow Indicator	FIT-G0571	0 - 700 GPM
GAC-PLC	AI	1	10	3	GAC Vessel 7N Pressure Differential Indicator	PDIT-G0571	0 - 125 PSIG
GAC-PLC	AI	1	10	4	Spare Point		
GAC-PLC	AI	1	10	5	Spare Point		
GAC-PLC	AI	1	11	0	GAC Vessel 7S Influent Flow Indicator	FIT-G0671	0 - 700 PSIG
GAC-PLC	AI	1	11	1	GAC Vessel 7S Pressure Differential Indicator	PDIT-G0671	0 - 125 PSIG
GAC-PLC	AI	1	11	2	GAC Vessels Common Effluent TOC Indicator	AI-G0500	0 - 10 mg/L
GAC-PLC	AI	1	11	4	Spare Point		
GAC-PLC	AI	1	11	4	Spare Point		
GAC-PLC	AI	1	11	5	Spare Point		
GAC-PLC	Slot Filler	1	12	--	Spare Slot		

GPS - PLC INPUT / OUTPUT SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
GPS-PLC	CPU	0	0	--	PLC Processor		
GPS-PLC	ENET	0	1	--	Ethernet/IP Communication Bridge		
GPS-PLC	DI	0	2	0	GAC Feed Pump No. 1 in Remote	VFD	--
GPS-PLC	DI	0	2	1	GAC Feed Pump No. 1 Run Status	VFD	--
GPS-PLC	DI	0	2	2	GAC Feed Pump No. 1 VFD Fault	VFD	--
GPS-PLC	DI	0	2	3	GAC Feed Pump No. 1 Monitoring System Fault	VFD	--
GPS-PLC	DI	0	2	4	GAC Feed Pump No. 1 Discharge Pressure High	PSH-P0111	--
GPS-PLC	DI	0	2	5	GAC Feed Pump No. 1 E-Stop	LCS	--
GPS-PLC	DI	0	2	6	GAC Feed Pump No. 2 in Remote	VFD	--
GPS-PLC	DI	0	2	7	GAC Feed Pump No. 2 Run Status	VFD	--
GPS-PLC	DI	0	2	8	GAC Feed Pump No. 2 VFD Fault	VFD	--
GPS-PLC	DI	0	2	9	GAC Feed Pump No. 2 Monitoring System Fault	VFD	--
GPS-PLC	DI	0	2	10	GAC Feed Pump No. 2 Discharge Pressure High	PSH-P0112	--
GPS-PLC	DI	0	2	11	GAC Feed Pump No. 2 E-Stop	LCS	--
GPS-PLC	DI	0	2	12	Spare Point		--
GPS-PLC	DI	0	2	13	Spare Point		--

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
GPS-PLC	DI	0	2	14	Spare Point		--
GPS-PLC	DI	0	2	15	Spare Point		--
GPS-PLC	DI	0	3	0	GAC Feed Pump No. 3 in Remote	VFD	--
GPS-PLC	DI	0	3	1	GAC Feed Pump No. 3 Run Status	VFD	--
GPS-PLC	DI	0	3	2	GAC Feed Pump No. 3 VFD Fault	VFD	--
GPS-PLC	DI	0	3	3	GAC Feed Pump No. 3 Monitoring System Fault	VFD	--
GPS-PLC	DI	0	3	4	GAC Feed Pump No. 3 Discharge Pressure High	PSH-P0113	--
GPS-PLC	DI	0	3	5	GAC Feed Pump No. 3 E-Stop	LCS	--
GPS-PLC	DI	0	3	6	GAC wet well High Level Alarm	LSH-P0100	--
GPS-PLC	DI	0	3	7	GAC wet well Low Level	LSL-P0100	--
GPS-PLC	DI	0	3	8	Spare Point		--
GPS-PLC	DI	0	3	9	Spare Point		--
GPS-PLC	DI	0	3	10	Spare Point		--
GPS-PLC	DI	0	3	11	Spare Point		--
GPS-PLC	DI	0	3	12	Spare Point		--
GPS-PLC	DI	0	3	13	Spare Point		--
GPS-PLC	DI	0	3	14	Spare Point		--
GPS-PLC	DI	0	3	15	Spare Point		--
GPS-PLC	DI	0	4	0	Duke Power On	Paralleling Switchgear	--
GPS-PLC	DI	0	4	1	Generator No. 1 Alarm	Generator No. 1 LCP	--
GPS-PLC	DI	0	4	2	Generator No. 2 Alarm	Generator No. 2 LCP	--
GPS-PLC	DI	0	4	3	Generator No. 1 Running	Generator No. 1 LCP	--
GPS-PLC	DI	0	4	4	Generator No. 2 Running	Generator No. 2 LCP	--
GPS-PLC	DI	0	4	5	Generator No. 1 Low Fuel	Generator No. 1 LCP	--
GPS-PLC	DI	0	4	6	Generator No. 2 Low Fuel	Generator No. 2 LCP	--
GPS-PLC	DI	0	4	7	Spare Point		--
GPS-PLC	DI	0	4	8	Spare Point		--
GPS-PLC	DI	0	4	9	Spare Point		--
GPS-PLC	DI	0	4	10	Spare Point		--
GPS-PLC	DI	0	4	11	Spare Point		--
GPS-PLC	DI	0	4	12	Spare Point		--
GPS-PLC	DI	0	4	13	Spare Point		--
GPS-PLC	DI	0	4	14	Spare Point		--
GPS-PLC	DI	0	4	15	Spare Point		--
GPS-PLC	Slot Filler	0	5	--	Spare Slot		
GPS-PLC	DO	0	6	0	GPS-Remote I/O Fail	Interposing Relay	--
GPS-PLC	DO	0	6	1	GAC Feed Pump No. 1 Start/Stop	VFD	--
GPS-PLC	DO	0	6	2	GAC Feed Pump No. 2 Start/Stop	VFD	--
GPS-PLC	DO	0	6	3	GAC Feed Pump No. 3 Start/Stop	VFD	--
GPS-PLC	DO	0	6	4	Spare Point		

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
GPS-PLC	DO	0	6	5	Spare Point		
GPS-PLC	DO	0	6	6	Spare Point		
GPS-PLC	DO	0	6	7	Spare Point		
GPS-PLC	DO	0	6	8	Spare Point		
GPS-PLC	DO	0	6	9	Spare Point		
GPS-PLC	DO	0	6	10	Spare Point		
GPS-PLC	DO	0	6	11	Spare Point		
GPS-PLC	DO	0	6	12	Spare Point		
GPS-PLC	DO	0	6	13	Spare Point		
GPS-PLC	DO	0	6	14	Spare Point		
GPS-PLC	DO	0	6	15	Spare Point		
GPS-PLC	Slot Filler	0	7	--	Spare Slot		
GPS-PLC	Slot Filler	0	8	--	Spare Slot		
GPS-PLC	AI	0	9	0	GAC Feed Pump No. 1 Speed Indicator	VFD	0 - 100%
GPS-PLC	AI	0	9	1	GAC Feed Pump No. 2 Speed Indicator	VFD	0 - 100%
GPS-PLC	AI	0	9	2	GAC Feed Pump No. 3 Speed Indicator	VFD	0 - 100%
GPS-PLC	AI	0	9	3	GAC Wet Well Level Indication	LIT-P0100	0 - 15. 5 FT
GPS-PLC	AI	0	9	4	GAC Flow	FIT-P0100	0 - 13 MGD
GPS-PLC	AI	0	9	5	Spare Point		
GPS-PLC	Slot Filler	0	10	--	Spare Slot		
GPS-PLC	AO	0	11	0	GAC Feed Pump No. 1 Speed Setpoint	VFD	0 - 100%
GPS-PLC	AO	0	11	1	GAC Feed Pump No. 2 Speed Setpoint	VFD	0 - 100%
GPS-PLC	AO	0	11	2	GAC Feed Pump No. 3 Speed Setpoint	VFD	0 - 100%
GPS-PLC	AO	0	11	3	Spare Point		
GPS-PLC	AO	0	11	4	Spare Point		
GPS-PLC	AO	0	11	5	Spare Point		
GPS-PLC	Slot Filler	0	12	--	Spare Slot		

PT - PLC INPUT / OUTPUT SCHEDULE							
PLC PANEL	**MOD**	**RACK**	**SLOT**	**POINT**	**Description/Location**	**Input from/Output to**	**Calibrated Range**
PT-PLC	CPU	0	0	--	PLC Processor		
PT-PLC	ENET	0	1	--	Ethernet/IP Communication Bridge		
PT-PLC	DI	0	2	0	Flocculation Basin No. 1 Mixer in Remote	VFD	--
PT-PLC	DI	0	2	1	Flocculation Basin No. 1 Mixer Run Status	VFD	--
PT-PLC	DI	0	2	2	Flocculation Basin No. 1 Mixer E-Stop	LCS	--
PT-PLC	DI	0	2	3	Flocculation Basin No. 1 Mixer Fault	VFD	--
PT-PLC	DI	0	2	4	Flocculation Basin No. 2 Mixer in Remote	VFD	--
PT-PLC	DI	0	2	5	Flocculation Basin No. 2 Mixer Run Status	VFD	--
PT-PLC	DI	0	2	6	Flocculation Basin No. 2 Mixer E-Stop	LCS	--
PT-PLC	DI	0	2	7	Flocculation Basin No. 2 Mixer Fault	VFD	--

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
PT-PLC	DI	0	2	8	Flocculation Basin No. 3 Mixer in Remote	VFD	--
PT-PLC	DI	0	2	9	Flocculation Basin No. 3 Mixer Run Status	VFD	--
PT-PLC	DI	0	2	10	Flocculation Basin No. 3 Mixer E-Stop	LCS	--
PT-PLC	DI	0	2	11	Flocculation Basin No. 3 Mixer Fault	VFD	--
PT-PLC	DI	0	2	12	Spare Point		
PT-PLC	DI	0	2	13	Spare Point		
PT-PLC	DI	0	2	14	Spare Point		
PT-PLC	DI	0	2	15	Spare Point		
PT-PLC	DI	0	3	0	Flocculation Basin No. 4 Mixer in Remote	VFD	--
PT-PLC	DI	0	3	1	Flocculation Basin No. 4 Mixer Run Status	VFD	--
PT-PLC	DI	0	3	2	Flocculation Basin No. 4 Mixer E-Stop	LCD	--
PT-PLC	DI	0	3	3	Flocculation Basin No. 4 Mixer Fault	VFD	--
PT-PLC	DI	0	3	4	Rapid Mixer No. 1 in Remote	VFD	--
PT-PLC	DI	0	3	5	Rapid Mixer No. 1 Run Status	VFD	--
PT-PLC	DI	0	3	6	Rapid Mixer No. 1 E-Stop	LCD	--
PT-PLC	DI	0	3	7	Rapid Mixer No. 1 Fault	VFD	--
PT-PLC	DI	0	3	8	Rapid Mixer No. 2 in Remote	VFD	--
PT-PLC	DI	0	3	9	Rapid Mixer No. 2 Run Status	VFD	--
PT-PLC	DI	0	3	10	Rapid Mixer No. 2 E-Stop	LCD	--
PT-PLC	DI	0	3	11	Rapid Mixer No. 2 Fault	VFD	--
PT-PLC	DI	0	3	12	Spare Point		
PT-PLC	DI	0	3	13	Spare Point		
PT-PLC	DI	0	3	14	Spare Point		
PT-PLC	DI	0	3	15	Spare Point		
PT-PLC	DI	0	4	0	Detector Residual Pump No. 1 Presence/Absence	MCC	--
PT-PLC	DI	0	4	1	Detector Residual Pump No. 2 Presence/Absence	MCC	--
PT-PLC	DI	0	4	2	Residual Pump No. 1 E-Stop	LCS	--
PT-PLC	DI	0	4	3	Residual Pump No. 1 in Remote	MCC	--
PT-PLC	DI	0	4	4	Residual Pump No. 1 Run Status	MCC	--
PT-PLC	DI	0	4	5	Residual Pump No. 1 Discharge Pressure High	MCC	--
PT-PLC	DI	0	4	6	Residual Pump No. 1 Overload	MCC	--
PT-PLC	DI	0	4	7	Residual Pump No. 1 Motor Temperature High	MCC	--
PT-PLC	DI	0	4	8	Residual Pump No. 2 E-Stop	LCS	--
PT-PLC	DI	0	4	9	Residual Pump No. 2 Run Status	MCC	--
PT-PLC	DI	0	4	10	Residual Pump No. 2 Discharge Pressure High	MCC	--
PT-PLC	DI	0	4	11	Residual Pump No. 2 in Remote	MCC	--
PT-PLC	DI	0	4	12	Residual Pump No. 2 Overload	MCC	--
PT-PLC	DI	0	4	13	Spare Point		
PT-PLC	DI	0	4	14	Spare Point		
PT-PLC	DI	0	4	15	Spare Point		

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
PT-PLC	DI	0	5	0	Residual Pump No. 2 Motor Temperature High	MCC	--
PT-PLC	DI	0	5	1	Sedimentation Basin No. 1 Thickener in Remote	MCC	--
PT-PLC	DI	0	5	2	Sedimentation Basin No. 1 Thickener Run Status	MCC	--
PT-PLC	DI	0	5	3	Sedimentation Basin No. 1 Thickener E-Stop	LCS	--
PT-PLC	DI	0	5	4	Sedimentation Basin No. 1 Thickener Overload	MCC	--
PT-PLC	DI	0	5	5	Sedimentation Basin No. 1 Thickener Torque High	MCC	--
PT-PLC	DI	0	5	6	Sedimentation Basin No. 2 Thickener in Remote	LCS	--
PT-PLC	DI	0	5	7	Sedimentation Basin No. 2 Thickener Run Status	MCC	--
PT-PLC	DI	0	5	8	Sedimentation Basin No. 2 Thickener E-Stop	LCS	--
PT-PLC	DI	0	5	9	Sedimentation Basin No. 2 Thickener Overload	MCC	--
PT-PLC	DI	0	5	10	Sedimentation Basin No. 2 Thickener Torque High	MCC	--
PT-PLC	DI	0	5	11	Equalization Pump No. 1 Run Status	MCC	--
PT-PLC	DI	0	5	12	Equalization Pump No. 1 E-Stop	LCS	--
PT-PLC	DI	0	5	13	Spare Point		
PT-PLC	DI	0	5	14	Spare Point		
PT-PLC	DI	0	5	15	Spare Point		
PT-PLC	DI	0	6	0	Raw Water Sample Pump in Remote	LCS	--
PT-PLC	DI	0	6	1	Raw Water Sample Pump Run Status	MCC	--
PT-PLC	DI	0	6	2	Raw Water Sample Pump Overload	MCC	--
PT-PLC	DI	0	6	3	Equalization Pump No. 1 Overload	MCC	--
PT-PLC	DI	0	6	4	Equalization Pump No. 2 Run Status	MCC	--
PT-PLC	DI	0	6	5	Equalization Pump No. 2 E-Stop	LCS	--
PT-PLC	DI	0	6	6	Equalization Pump No. 2 in Remote	LCS	--
PT-PLC	DI	0	6	7	Equalization Pump No. 2 Leak Detection	MCC	--
PT-PLC	DI	0	6	8	Equalization Pump No. 2 Motor Temperature High	MCC	--
PT-PLC	DI	0	6	9	Equalization Pump No. 2 Overload	MCC	--
PT-PLC	DI	0	6	10	Equalization Wet well High Level Alarm	LSH-G0800	--
PT-PLC	DI	0	6	11	Equalization Wet well Low Level Alarm	LSL-G0800	--
PT-PLC	DI	0	6	12	Spare Point		
PT-PLC	DI	0	6	13	Spare Point		
PT-PLC	DI	0	6	14	Spare Point		
PT-PLC	DI	0	6	15	Spare Point		
PT-PLC	DI	0	7	0	Filter Influent Drain Valve Opened	Valve Actuator	--
PT-PLC	DI	0	7	1	Filter Influent Drain Valve Closed	Valve Actuator	--
PT-PLC	DI	0	7	2	Raw Water Sample Pump in Remote	MCC	--
PT-PLC	DI	0	7	3	Raw Water Sample Pump Run Status	MCC	--
PT-PLC	DI	0	7	4	Raw Water Sample Pump Overload	MCC	--
PT-PLC	DI	0	7	5	Settled Water Sample Pump in Remote	MCC	--
PT-PLC	DI	0	7	6	Settled Water Sample Pump Run Status	MCC	--
PT-PLC	DI	0	7	7	Settled Water Sample Pump Overload	MCC	--

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
PT-PLC	DI	0	7	8	Spare Point		
PT-PLC	DI	0	7	9	Spare Point		
PT-PLC	DI	0	7	10	Spare Point		
PT-PLC	DI	0	7	11	Spare Point		
PT-PLC	DI	0	7	12	Spare Point		
PT-PLC	DI	0	7	13	Spare Point		
PT-PLC	DI	0	7	14	Spare Point		
PT-PLC	DI	0	7	15	Spare Point		
PT-PLC	DO	0	8	0	PT-Remote I/O Fail	Interposing Relay	--
PT-PLC	DO	0	8	1	Flocculation Basin No. 1 Mixer Start/Stop	VFD	--
PT-PLC	DO	0	8	2	Flocculation Basin No. 2 Mixer Start/Stop	VFD	--
PT-PLC	DO	0	8	3	Flocculation Basin No. 3 Mixer Start/Stop	VFD	--
PT-PLC	DO	0	8	4	Flocculation Basin No. 4 Mixer Start/Stop	VFD	--
PT-PLC	DO	0	8	5	Rapid Mixer No. 1 Start/Stop	VFD	--
PT-PLC	DO	0	8	6	Rapid Mixer No. 2 Start/Stop	VFD	--
PT-PLC	DO	0	8	7	Residual Pump No. 1 Start/Stop	MCC	--
PT-PLC	DO	0	8	8	Residual Pump No. 2 Start/Stop	MCC	--
PT-PLC	DO	0	8	9	Sedimentation Basin No. 1 Thickener Start/Stop	MCC	--
PT-PLC	DO	0	8	10	Sedimentation Basin No. 2 Thickener Start/Stop	MCC	--
PT-PLC	DO	0	8	11	Equalization Pump No. 1 Start/Stop	MCC	--
PT-PLC	DO	0	8	12	Spare Point		--
PT-PLC	DO	0	8	13	Spare Point		
PT-PLC	DO	0	8	14	Spare Point		
PT-PLC	DO	0	8	15	Spare Point		
PT-PLC	DO	0	9	0	Equalization Pump No. 2 Start/Stop	MCC	--
PT-PLC	DO	0	9	1	Filter Influent Drain Valve Open	Valve Actuator	--
PT-PLC	DO	0	9	2	Filter Influent Drain Valve Close	Valve Actuator	--
PT-PLC	DO	0	9	3	Raw Water Sample Pump Start/Stop	MCC	--
PT-PLC	DO	0	9	4	Settled Water Sample Pump Start/Stop	MCC	--
PT-PLC	DO	0	9	5	Spare Point		
PT-PLC	DO	0	9	6	Spare Point		
PT-PLC	DO	0	9	7	Spare Point		
PT-PLC	DO	0	9	8	Spare Point		
PT-PLC	DO	0	9	9	Spare Point		
PT-PLC	DO	0	9	10	Spare Point		
PT-PLC	DO	0	9	11	Spare Point		
PT-PLC	DO	0	9	12	Spare Point		
PT-PLC	DO	0	9	13	Spare Point		
PT-PLC	DO	0	9	14	Spare Point		
PT-PLC	DO	0	9	15	Spare Point		

TAYLOR MILL WATER TRATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
INPUT / OUTPUT (I/O) SCHEDULE

PLC PANEL	MOD	RACK	SLOT	POINT	Description/Location	Input from/Output to	Calibrated Range
PT-PLC		0	10		Blank Slot Filler		
PT-PLC		0	11		Blank Slot Filler		
PT-PLC		0	12		Blank Slot Filler		
PT-PLC	AI	0	13	0	Flocculation Outlet pH Indicator	AI-G0201	0 - 14 pH
PT-PLC	AI	0	13	1	Flocculation Basin No. 1 Mixer Speed Indicator	VFD	0 - 100%
PT-PLC	AI	0	13	2	Flocculation Basin No. 2 Mixer Speed Indicator	VFD	0 - 100%
PT-PLC	AI	0	13	3	Flocculation Basin No. 3 Mixer Speed Indicator	VFD	0 - 100%
PT-PLC	AI	0	13	4	Flocculation Basin No. 4 Mixer Speed Indicator	VFD	0 - 100%
PT-PLC	AI	0	13	5	Spare Point		
PT-PLC	AI	0	14	0	Rapid Mixer No. 1 Speed Indicator	VFD	0 -100%
PT-PLC	AI	0	14	1	Rapid Mixer No. 2 Speed Indicator	VFD	0 -100%
PT-PLC	AI	0	14	2	Raw Water Flow Indicator	FIT-G0201	0 - 13 MGD
PT-PLC	AI	0	14	3	Raw Water Turbidity Indicator	AI-G0200	0 - 999.9 NTU
PT-PLC	AI	0	14	4	Equalization Wet Well Level Indication	LIT-G0800	0 - 10.5 FT
PT-PLC	AI	0	14	5	Spare Point		
PT-PLC	AO	0	15	0	Flocculation Basin No. 1 Mixer Speed Setpoint	VFD	0 - 100%
PT-PLC	AO	0	15	1	Flocculation Basin No. 2 Mixer Speed Setpoint	VFD	0 - 100%
PT-PLC	AO	0	15	2	Flocculation Basin No. 3 Mixer Speed Setpoint	VFD	0 - 100%
PT-PLC	AO	0	15	3	Flocculation Basin No. 4 Mixer Speed Setpoint	VFD	0 - 100%
PT-PLC	AO	0	15	4	Spare Point		
PT-PLC	AO	0	15	5	Spare Point		
PT-PLC	AO	0	16	0	Rapid Mixer No. 1 Speed Setpoint	VFD	0 - 100%
PT-PLC	AO	0	16	1	Rapid Mixer No. 2 Speed Setpoint	VFD	0 - 100%
PT-PLC	AO	0	16	2	Spare Point		
PT-PLC	AO	0	16	3	Spare Point		
PT-PLC	AO	0	16	4	Spare Point		
PT-PLC	AO	0	16	5	Spare Point		

SECTION 13453

DEVICENET

PART 1 - GENERAL

1.1 DESCRIPTION

A. Furnish and install DeviceNet networks as shown and specified. The networks shall be arranged such that future nodes can be added at any point(s) along the network without overloading the system or requiring re-routing of the DeviceNet cable being installed under this contract. Refer to Specification Section 15100, Valves and Appurtenances for valve actuator requirements.

B. Topology shall be as shown on the Drawings. Provide all Deviceboxes, inline surge suppressors, terminating resistors, enclosures, wire, cabling, tubing, piping, conduit, cable tray, fittings, supports, junction boxes, repeaters, taps, connectors, interfaces, accessories and appurtenances to provide a fully functional DeviceNet network.

C. Quality Assurance:

1. The DeviceNet Network shall be furnished by the Instrumentation and Control System (ICS) Supplier who shall assume responsibility for providing a complete and integrated system.
2. All equipment, components and materials required shall be furnished by the ICS Supplier who shall assume the responsibility for adequacy and performance of all items.
3. The ICS Supplier shall have a minimum of five years experience in the production of substantially similar equipment and shall show evidence of at least five installations in satisfactory operation for at least three continuous years.
4. The ICS Supplier shall be a licensed member of Open DeviceNet Vendors Association (ODVA).

1.2 RELATED SECTIONS

A. Section 13401, Plant Monitoring and Control System General Requirement

B. Section 15100, Valves and Appurtenances

C. Section 16075, Electrical Identification

1.3 SUBMITTALS

A. Comply with the requirements of Section 13401, Plant Monitoring and Control System General Requirements.

B. Submit Declaration of Conformity for each product for each component on the DeviceNet network that it is certified by Open DeviceNet Vendors Association (ODVA).

C. The Contractor shall submit to the Engineer a schedule of proposed drop line lengths for each drop for every circuit before the installation and submit an updated schedule in the O&M manual.

PART 2 - –PRODUCTS

2.1 DEVICENET EQUIPMENT

A. DeviceNet network and installation shall meet or exceed ODVA guidelines and requirements. DeviceNet network and installation shall meet or exceed manufacturer's requirements.

B. DeviceNet Components
   1. Provide components as indicated in the DeviceNet Component Schedule attached at the end of this section.
   2. Manufacturers and Models:
      a. 24 VDC, 8 amp DeviceNet Power Supply:
         1) Allen Bradley/Rockwell model number 1787-DNPS
      b. PowerTap:
         1) Allen Bradley/Rockwell model number 1485T-P2T5-T5
      c. DeviceBox:
         1) 4-port: Allen Bradley/Rockwell model number 1485P-P4T5-T5
      d. T-Port Tap: not permitted
   3. Size enclosures, junction boxes, conduit, and other components accordingly.

C. ControlLogix DeviceNet Communication Card:
   1. Provide Per Section 13451, Programmable Controller System.

D. Topology:
   1. DeviceNet interface at devices shall be a direct DeviceNet connection with no intermediate conversion from another communication protocol.
   2. Contractor shall not connect devices to the DeviceNet drop cable in a daisy chain configuration. Only one device shall be connected on any drop cable. The failure or disconnection of any DeviceNet node (on the drop cable) shall not disturb any other nodes or devices in the system.
   3. The cumulative trunk line distance in each DeviceNet circuit shall not exceed 1640 feet.
   4. Maximum length of any drop line shall not exceed 20 feet.

5. The cumulative drop line length on any one DeviceNet circuit shall not exceed 156 meters (512 feet).

E. Enclosures:
   1. Except for components mounted in existing or new PLC cabinets, all DeviceNet components (DeviceBoxes, and the like) shall be mounted in enclosures suitable for the environment for the area classification Schedule. Drop lines shall be landed on screw terminals on both ends. Components within panels shall be mounted on subplates.
   2. DeviceNet trunk line taps shall use a suitable DeviceBox for connection to no more than four devices. Enclosure size shall account for hardware size and the cable's minimum bend radius. Provide slack for all cables, conductors, cordsets, and patchcords to allow for future upgrades or revisions.

F. Provide PC configuration software to fully implement network monitoring and diagnostic functions for each type of network. Software shall be Rockwell RS-MACC or equal.

G. Contractor shall propose necessary network addresses, masking, and required custom configuration requirements for each network. Owner and Engineer shall have ultimate decisions on these configuration requirements and Contractor shall implement them accordingly.

H. Spares:
   1. Already confirmed on 13451
   2. Provide 5 spare DeviceNet DeviceBoxes
   3. Provide 2 spare DeviceNet DeviceBox enclosures
   4. Provide 1 spare DeviceNet Power Taps
   5. Provide 2 spare DeviceNet Power Supplies
   6. Provide 4 spare of each type of DeviceNet connectors used

PART 3 - EXECUTION

3.1 DEVICENET INSTALLATION

A. DeviceNet Cabling:
   1. Maintain shielding on conductors.
   2. Do not exceed minimum bend radius.
   3. The System Integrator is responsible for tagging of the DeviceNet cables. The DeviceNet Trunk Line cables shall be tagged according to "DeviceNet Trunk Segment Schedule" attached at the end of this Section. The DeviceNet Drop Cables shall be tagged with the same identification as the device it is connected to. Refer to Section 16075, Electrical Identification for tagging requirements.

B. System Integrator shall be responsible for furnishing all required hardware, software, and tools for configuring, testing, and troubleshooting the DeviceNet network.
   1. System Integrator shall complete a full setup, including assigning node addresses, baud rate and document the setup on configuration sheets. The configuration sheets shall clearly identify parameter settings, switch settings, software settings. These sheets shall be submitted for record.

C. Testing:
   1. After installation of the DeviceNet networks, the System Integrator shall test the networks with a suitable test meter such as the Woodhead DeviceNet Meter, Part No. DN-MTR or equivalent.
   2. CONTRACTOR shall provide to the OWNER the results of the tests and demonstrate to the OWNER that the network is “healthy” and exceeds or is “within spec” for EACH segment. Unacceptable test results include “normal”, “very close to limit”, “faulty”, and “out of limit”. Testing that generates results of warning or faults shall be repaired and retested so that there shall be no warnings or faults remaining after testing.
   3. Provide a testing report for each DeviceNet segment.

D. Manufacturer’s Support:
   1. Valve actuator manufacturer shall provide on-site support for DeviceNet configuration. Refer to Section 15100, Valves and Appurtances.

+ + END OF SECTION + +

TAYLOR MILL WATER TREATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
DEVICENET SCHEDULE

PLC	MODULE NUMBER	DESCRIPTION	DEVICE / EQUIPMENT IDENTIFICATION	TAP BOX IDENTIFICATION	SHEET REFERENCE
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	BWW/VTW-BFV-1N	TB-1-1	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GS-BFV-1N	TB-1-2	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GAC-BFV-1N	TB-1-3	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GTW-BFV-1N	TB-1-4	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	BWS-BFV-1N	TB-2-1	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	BWS-BFV-1S	TB-2-2	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	SPARE	TB-2-3	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	SPARE	TB-2-4	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	BWW/VTW-BFV-1S	TB-3-1	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GS-BFV-1S	TB-3-2	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GAC-BFV-1S	TB-3-3	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GTW-BFV-1S	TB-3-4	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	BWW/VTW-BFV-2N	TB-4-1	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GS-BFV-2N	TB-4-2	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GAC-BFV-2N	TB-4-3	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GTW-BFV-2N	TB-4-4	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	BWS-BFV-2N	TB-5-1	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	BWS-BFV-2S	TB-5-2	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	SPARE	TB-5-3	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	SPARE	TB-5-4	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	BWW/VTW-BFV-2S	TB-6-1	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GS-BFV-2S	TB-6-2	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GAC-BFV-2S	TB-6-3	I-06-604
GAC-PLC	GAC PLC-DNB1	GAC DeviceNet Network 1	GTW-BFV-2S	TB-6-4	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	BWW/VTW-BFV-3N	TB-7-1	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GS-BFV-3N	TB-7-2	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GAC-BFV-3N	TB-7-3	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GTW-BFV-3N	TB-7-4	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	BWS-BFV-3N	TB-8-1	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	BWS-BFV-3S	TB-8-2	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	SPARE	TB-8-3	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	SPARE	TB-8-4	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	BWW/VTW-BFV-3S	TB-9-1	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GS-BFV-3S	TB-9-2	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GAC-BFV-3S	TB-9-3	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GTW-BFV-3S	TB-9-4	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	BWW/VTW-BFV-4N	TB-10-1	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GS-BFV-4N	TB-10-2	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GAC-BFV-4N	TB-10-3	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GTW-BFV-4N	TB-10-4	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	BWS-BFV-4N	TB-11-1	I-06-604

TAYLOR MILL WATER TREATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
DEVICENET SCHEDULE

PLC	MODULE NUMBER	DESCRIPTION	DEVICE / EQUIPMENT IDENTIFICATION	TAP BOX IDENTIFICATION	SHEET REFERENCE
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	BWS-BFV-4S	TB-11-2	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	SPARE	TB-11-3	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	SPARE	TB-11-4	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	BWW/VTW-BFV-4S	TB-12-1	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GS-BFV-4S	TB-12-2	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GAC-BFV-4S	TB-12-3	I-06-604
GAC-PLC	GAC PLC-DNB2	GAC DeviceNet Network 2	GTW-BFV-4S	TB-12-4	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	BWW/VTW-BFV-5N	TB-13-1	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GS-BFV-5N	TB-13-2	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GAC-BFV-5N	TB-13-3	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GTW-BFV-5N	TB-13-4	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	BWS-BFV-5N	TB-14-1	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	BWS-BFV-5S	TB-14-2	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	SPARE	TB-14-3	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	SPARE	TB-14-4	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	BWW/VTW-BFV-5S	TB-15-1	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GS-BFV-5S	TB-15-2	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GAC-BFV-5S	TB-15-3	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GTW-BFV-5S	TB-15-4	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	BWW/VTW-BFV-6N	TB-16-1	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GS-BFV-6N	TB-16-2	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GAC-BFV-6N	TB-16-3	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GTW-BFV-6N	TB-16-4	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	BWS-BFV-6N	TB-17-1	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	BWS-BFV-6S	TB-17-2	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	SPARE	TB-17-3	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	SPARE	TB-17-4	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	BWW/VTW-BFV-6S	TB-18-1	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GS-BFV-6S	TB-18-2	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GAC-BFV-6S	TB-18-3	I-06-604
GAC-PLC	GAC PLC-DNB3	GAC DeviceNet Network 3	GTW-BFV-6S	TB-19-4	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	BWW/VTW-BFV-7N	TB-20-1	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	GS-BFV-7N	TB-20-2	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	GAC-BFV-7N	TB-20-3	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	GTW-BFV-7N	TB-20-4	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	BWS-BFV-7N	TB-21-1	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	BWS-BFV-7S	TB-21-2	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	SPARE	TB-21-3	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	SPARE	TB-21-4	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	BWW/VTW-BFV-7S	TB-22-1	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	GS-BFV-7S	TB-22-2	I-06-604

TAYLOR MILL WATER TREATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
DEVICENET SCHEDULE

PLC	MODULE NUMBER	DESCRIPTION	DEVICE / EQUIPMENT IDENTIFICATION	TAP BOX IDENTIFICATION	SHEET REFERENCE
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	GAC-BFV-7S	TB-22-3	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	GTW-BFV-7S	TB-22-4	I-06-604
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	BWS-BFV-3	TB-23-1	I-06-603
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	SBWS-BFV-3	TB-23-2	I-06-603
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	SPARE	TB-23-3	I-06-603
GAC-PLC	GAC PLC-DNB4	GAC DeviceNet Network 4	SPARE	TB-23-4	I-06-603

TAYLOR MILL WATER TREATMENT PLANT
ADVANCED TREATMENT IMPROVEMENTS
DEVICENET SCHEDULE

PLC	MODULE NUMBER	DESCRIPTION	DEVICE / EQUIPMENT IDENTIFICATION	TAP BOX IDENTIFICATION	SHEET REFERENCE

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SECTION 13701

SURVEILLENCE AND ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, material, equipment and incidentals as shown, specified and required to furnish, install, test and place into satisfactory operation a Security System as specified herein. This system shall be comprised of a Surveillance System and a Security Access Control Management (SACM) System.
   2. This section covers the furnishing and installation of an access control system and accessories that must interface with the existing access control system.
   3. The installation shall include programming the existing server to accept the new access control system. The new system shall be programmed similar to the other buildings at the plant.

B. The specifications describe the minimum requirements for hardware. Where Supplier's standard configuration includes additional items of equipment features not specifically described herein, such equipment or features shall be furnished as a part of the system. The CONTRACTOR shall provide all material, equipment, and labor necessary to complete the work properly.

C. The new system must be fully compatible with the existing DSX Access Control System.

D. CONTRACTOR shall employ the services of a Security System Supplier with proven experience in the field. Security System Supplier shall assume full responsibility for the selection of equipment and components required. Specifically this shall include defining the required system components, preparing detailed system schematics, interconnecting wiring diagrams, field debugging, calibrating, and configuring the system as well as instructing plant personnel on the care and use of the system.

E. Design, installation, service support, and otherwise known as supplier, shall be:
   1. Aegis Protective Services
      3033 Robertson Avenue
      Cincinnati, OH 45209
      Contact: George Wergers
      Phone: 513-948-0066, ext. 108

F. The surveillance and SACM systems provided shall be turnkey system solutions, wherein each component is seamlessly integrated with the overall system. The CCTV System shall employ common controls communications protocol and video signal formats throughout. The SACM System shall employ common controls communications protocol and access control data formats throughout.

G. All cameras shall be connected via Ethernet on a dedicated network. Utilizing dedicated fibers on shared fiber optic cable is permitted, but all Ethernet networking equipment must be dedicated to the purpose of the surveillance system and must comply with Section 13451.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American National Standards Institute, (ANSI).
   2. Factory Mutual, (FM).
   3. Institute of Electrical and Electronic Engineers, (IEEE).
   4. National Electrical Code, (NEC).
   5. National Electrical Manufacturers Association, (NEMA).
   6. Underwriters' Laboratories, Inc., (UL).
   7. American Society for Testing and Materials, (ASTM).
   8. American Wire Gage, (AWG).
   9. Electronic Industries Association, (EIA).
   10. Federal Communications Commission, (FCC).

1.3 QUALITY ASSURANCE

A. In order to ensure standardization, proper interfacing and compatibility, it is required that all equipment offered under this Section be furnished by a single Supplier who shall provide all equipment required for a proper installation and coordinate all Shop Drawings.

B. The Security System Supplier shall be responsible for providing all components and software for the surveillance and access control systems.

C. All items of equipment, including wire and cable, shall be compatible.

D. The Security System Supplier shall provide on-site manufacturer’s representatives to oversee installation and to verify that installation of all equipment is in compliance with manufacturer requirements. Supplier shall provide a written report verifying that the installation is complete, fully functional, and in compliance with all manufacturer requirements.

E. Supplier shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective installation or materials, and leakage, breakage, or

other failure. Materials shall be suitable for service conditions. Equipment shall not have been in service at any time prior to delivery, except for testing.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Product Data:
      a. Manufacturer's literature, illustrations, specifications and engineering data including: general arrangement, outline drawings, dimensions, materials, size, weight, and performance data.
   2. Shop Drawings:
      a. Fabrication, assembly, and installation drawings.
      b. Complete riser diagrams clearly labeling all conduit and wire.
      c. Layout drawings with conduit and equipment numbers.
      d. Block Diagram: Provide system diagram noting major system components and interrelationship of each component.
      e. Interconnection Diagram: Provide detailed drawing noting interconnecting cable and labeled connections for all closed circuit television (CCTV) equipment.
      f. Prove existing network “as-built” drawings before installation of any new equipment. Drawings shall indicate make and model of all equipment, addresses, and locations, media type, converters, panels, etc.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. Certificates of Compliance/Manufacture.
   2. Supplier Instructions:
      a. Installation Instructions.
   3. Source Quality Control Submittals:
      a. Submit reports for all required shop tests.
   4. Site Quality Control Submittals:
      a. Submit reports for all required field-tests
      b. Submit reports for all manufacturer's site visits

C. Closeout Submittals: Submit the following:
   1. Operation and Maintenance Manuals:
      a. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.
      b. Furnish operation and maintenance manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.
   2. Operating and Maintenance Manuals List:
      a. Hardware and peripherals.
      b. Definition of terms and functions.

c. System start-up and shutdown procedures.
d. Use of system and applications software.
e. Recovery and restart procedures.
f. Graphic alarm presentation.
g. Alarm reports and printing formats.
h. Use of report generator and generation of reports.
i. Date entry.
j. Operator commands.

3. Software:
   a. Software Manuals.

D. Maintenance Materials Submittals: Furnish the following:
1. Spare Parts:
   a. Spare parts and consumable items shall be provided as specified. All spare parts shall be delivered to the OWNER before final acceptance of the system. Packaging of spare parts shall provide protection against dust and moisture and shall be suitable for storage. Electronic parts shall be enclosed in anti static material. All spare parts shall be clearly marked with the manufacturer's name, part number, date of manufacture, and approximate shelf life. Supplier may utilize spare parts and supplies during system installation and testing but shall restore or replace all such materials and supplies to the specified quantities before final acceptance of the system.
2. Supplier shall provide the following spare parts:
   a. One (1) power supply of each type used.
   b. One (1) Card Reader of each type used.
   c. Two (2) door contacts with relays of each type used.
   d. Two (2) hatch limit switches of each type used.
   e. One (1) Keypad of each type used.
3. Tools.
4. List of all special tools required for routine maintenance.

E. Power Supply
1. Unless otherwise specified, power supply to all equipment will be 120 volts, 60 Hz, single phase. Supplier shall be responsible for supplying power to all access control system panels. Supplier shall be responsible for distribution of power among enclosures, consoles, peripherals, and other components of the system. Power distribution hardware shall include cables and branch circuit over-current protection.

1.5 DELIVERY AND PRODUCT STORAGE

A. Security, process monitoring and access control equipment shall be delivered, stored and handled in accordance with Division 01, General Requirements, the manufacturer's instructions, and the following.

1. Security, process monitoring and access control equipment shall be inspected by CONTRACTOR for shipping damage or loose parts when received. Evidence of water, which may have entered equipment during transit, shall be checked.
2. Equipment shall be stored in a clean, dry location in which a uniform temperature is maintained. Equipment shall be protected with coverings and maintain air circulation.
3. Where dampness or condensation may be encountered, heaters shall be provided for equipment to prevent moisture damage.

1.6 PREPARATION FOR SHIPMENT

A. All electronic equipment and instruments shall be suitably packaged to facilitate handling and to protect against damage during transit and storage. All equipment shall be boxed, crated, or otherwise completely enclosed and protected during shipment, handling, and storage. All equipment shall be protected from exposure to the elements; shall be kept dry at all times, and shall not be exposed to adverse weather conditions.

B. Painted surfaces shall be protected against damage by impact, abrasion, discoloration, or other conditions. Painted surfaces that are damaged prior to acceptance of the system shall be repainted to the satisfaction of the OWNER.

1.7 SYSTEM OVERVIEW

A. The system shall be a PC-based access control system used to control and monitor personnel and alarm activity. Supplier shall coordinate with the OWNER for connection to existing hardware and network systems. The existing software used by the OWNER is WinDSX and it shall be used by the Supplier to operate and configure the new access control system.

B. Access Control:
   1. A card reader at a door shall unlock the primary door and allow access into the building. The card reader shall function properly by using the proximity card or by entering the code on the keypad. Operating the card reader a second time shall reset the system and reactivate the door alarms. If an employee fails to reset the system, it shall automatically reset at 5:00 p.m and the system shall identify the last person of entry.
   2. Contact switches on access hatches shall activate an alarm to SCADA only.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. The Surveillance system shall provide surveillance of plant entrances and areas specified in the Table 2. The surveillance System installed under this Contract shall be independent of any previously installed security equipment.

Table 1 –SACM Components

Building	Room	Location	Card Read	Door Strike	Contacts
PT/GAC	102A	Northeast near stairs	1	1	1
PT/GAC	103A	Northeast near stairs	1	1	1
PT/GAC	103B	East roll-up			1
PT/GAC	103C	Near East roll-up	1	1	1
PT/GAC	103D	West roll-up			1
PT/GAC	103E	Near West roll-up	1	1	1
PT/GAC	104A	Admin entry	1	1	1
PT/GAC	107A	Corridor entry	1	1	1
PT/GAC	107B	Corridor entry	1	1	1
PT/GAC	109A	Electrical room entry	1	1	1
PT/GAC	109B	Electrical room entry			2
PT/GAC	205	2nd floor roof			1
PT/GAC	401	4th floor roof			1
GPS	101A	Double door	1	1	2
GPS	101B	Electrical room entry	1	1	1
GPS	103	West entry	1	1	1
GPS	-	Roof			1
GPS	103	Roll-up			1
SLUDGE	-	FTWR Meter Vault Hatch			1

Table 2 – Camera Locations

Building	Room	Location*	Camera	Camera Location
PT/GAC	103C	Near E Roll-Up	1 Fixed	Inside facing truck off loading area
PT/GAC	103D	W Roll-Up	1 Fixed	Indoor camera facing off loading area
PT/GAC	103E	Near W Roll-Up	2 Fixed	Outside facing north the second one facing south
PT/GAC	105A	Lab Entry	1 Fixed	Outdoor door facing north
PT/GAC	107A	Corridor Entry	1 Fixed	Outdoor facing door entry
PT/GAC	107B	Corridor Entry	1 Fixed	Indoor facing door entry
PT/GAC	109B	Electrical Room Entry	1 Fixed	Outdoor facing old Grand Ave gate
PT/GAC	Outside	SW Corner	1 Fixed	Facing new Grand Ave gate
PT/GAC	Outside	E Center	2 Fixed	Facing opposite each other N & S direction
PT/GAC	Outside	NE Corner	1 Fixed	Facing creek
PT/GAC	203	SE Corner	1 PTZ	Rapid Mix
PT/GAC	205	S Center	1 PTZ	Effluent to Filter

* Note: Coordinate exact location and mounting height with Owner. Obtain approval of Owner before installing.

B. The Surveillance system shall include the following:
   1. Pan/Tilt/Zoom and Fixed cameras contained in outdoor enclosures.
   2. Video monitoring computers provided for monitoring and control of all cameras.
   3. One rack-mounted digital recorder/server located in (Refer Table 1 and Notes).
   4. Contactor shall provide all the necessary cables as required.

C. The SACM system shall monitor and control access throughout specified locations (Refer Table 1 & 2). The SACM system shall also monitor and provide access control to the locations specified in Table 1 & 2. The system shall include the following:
   1. Card readers to control access at the plant entrances and the other specified areas of plant (Refer Table 1 & 2 for location information).
   2. Card readers and magnetic door latches to control access to selected offices and equipment rooms (Refer Table 1 & 2 for location information).
   3. Existing SACM System Database shall maintain records of all movements through secured entrances (Refer Table 1 & 2 for location information).

D. Configuration of the Plant Security System shall be coordinated with the OWNER and the ENGINEER. At a minimum, the system shall be configured as follows:

1. For all fixed cameras at entrance gates, provide continuous recording during normal operating hours. After hours, cameras shall switch to motion detection mode and only record when vehicles are detected entering/leaving facility.
2. For all PTZ (Pan-Tilt-Zoom) cameras at entrance gates, provide, at a minimum, four distinct preset camera positions to be coordinated with the OWNER. System shall be configured to scan through presets on demand. Recording shall be continuous during normal working hours.
3. The Video Monitoring Computers shall be configured as follows:
    a. Existing computer shall be configured to allow manual access to all plant cameras, as well as the SACM System Computer information.
    b. Existing computer shall be configured to provide a complete guard tour of entire facility on the hour every hour. The guard tour shall consist of 10-second displays of every camera on the system.
4. SACM card readers shall be configured as follows:
    a. Flash green on a card read, LED normally red.

E. Suitably regulated electrical power shall be provided to all equipment and components furnished under this Section. Supplier shall furnish alternate power supplies, as required, suitable to drive components utilizing different voltages. Surge arrestors shall be provided, as required, to protect all equipment from power surges and voltage spikes.

2.2 CAMERAS

A. General: All cameras shall be compatible with Pelco DX8100 series DVR and shall be IP addressable. Provide Fixed and Pan-Tilt-Zoom Cameras as shown in Table 1 & 2. The environmental camera system shall consist of an outdoor camera and housing designed specifically for use in moderate to severe climate conditions and shall include thermostatically controlled heater, window defroster/defogger, sun shroud, viewing window wiper and insulation blanket along with any accessories which may be required for a complete environmental camera system. The camera system shall be able to transmit/receive video and data over Ethernet. All mounting hardware shall be furnished with the system. Cameras and mounting hardware type shall be as shown.

B. Pan-Tilt Camera Features:
1. Type: High Resolution, Color, Integrated Receiver, Low Light Sensitivity.
2. Provide pan and tilt drive where indicated:
    a. Pan:
        1) Adjustable speed.
        2) Preset Speed: 100 degrees per second.
        3) Movement: 360 degrees continuous pan rotation.
    b. Tilt:
        1) Adjustable speed.
        2) Preset Speed: 30 degrees per second.
        3) Movement: Unobstructed +40 degrees to -90 degrees from horizontal.
3. Zoom: Lens: f/1.4 (f = 4.1-73.8 optical, 18 optical zoom, 4X electronic zoom).

4. Signal Format: NTSC.
5. Scanning System: 2:1 interlace.
6. Image Sensor: 1/4-inch interlines transfer CCD.
7. Effective Pixels: 768 (H) x 494 (V).
8. Horizontal Resolution: > 540 TV lines.
9. Focus: Automatic with manual override.
10. Sensitivity: 0.02 lux at 1/4-second shutter speed.
11. Shutter Speed: Automatic (electronic iris)/manual - 1/4-1/10,000.
12. Iris Control: Automatic with manual override.
13. Electrical:
    a. Input Voltage: 120 VAC.
    b. Maximum Power Consumption: 50 VA per system.
    c. Camera and Lens Voltage: 24 VAC.
14. Mounting Brackets:
    a. All mounting brackets shall be of corrosion-resistant construction and shall be load rated to support camera, housing and pan and tilt drive components and accessories specified herein. Mounting heads shall be manually adjustable.
    b. Mounting shall be suitable for pole, wall, or parapet mounting as shown on the Contract Drawing.
        1) Wall mounted brackets, Pelco Model IWM-G4 or equivalent.
        2) Pole adapter, Pelco Model PA402 or equivalent.
15. Environmental Enclosure:
    a. NEMA 4X rated.
    b. Maximum Wind Condition: Operational in 90 mph winds.
    c. Material: Die-cast, extruded and sheet aluminum; stainless steel.
    d. Viewing Window: 0.2-inch thick, optically-clear, impact resistant.
    e. Operating Temperature: -40° to 122°F.

C. Fixed Camera Features:
1. Type: High Resolution, Color, Enhanced Sensitivity.
2. Zoom Lens: f/1.3, 30X zoom, Model 13ZD, by Pelco, or equal.
3. Signal Format: NTSC
4. Scanning System: 2:1 interlace.
5. Image Sensor: 1/4-inch interline transfer CCD.
6. Effective Pixels: 768 (H) x 494 (V).
7. Horizontal Resolution: 480 TV lines.
8. Focus: Automatic with manual override.
9. Sensitivity: 0.02 lux at 1/4-second shutter speed.
10. Shutter Speed: Automatic (electronic iris)/manual - 1/4-1/10,000.
11. Iris Control: Automatic with manual override.
12. Electrical:
    a. Input Voltage: 120 VAC.
    b. Maximum Power Consumption: Ten Watts.
    c. Camera and Lens Voltage: 24 VAC.
13. Mounting Brackets:

a. All mounting brackets shall be of corrosion-resistant construction and shall be load rated to support camera and accessories specified herein. Mounting heads shall be adjustable.
b. Mounting shall be suitable for pole, wall, or parapet mounting as shown on the Contract Drawings
1) For pole mounting, provide the EM-2000 Pole Mount, by Pelco, or equal.
2) For wall mounting

14. Environmental Enclosure:
a. NEMA 4X rated.
b. Maximum Wind Condition: Operational in 90 mph winds.
c. Material: Die-cast, extruded and sheet aluminum.
d. Viewing Window: 0.2-inch thick, optically clear, impact resistant.
e. Operating Temperature: -40° to 122°F.
f. Provide EH-3512-2 enclosure with 24 VAC and blower.

D. Surge Protection:
1. Each camera shall be protected with surge protection device at each end of the cable, at the camera site and the head end equipment where the cabling is connected to the fiber-optic backbone.

E. Products and Manufacturers: Provide one of the following:
1. For Pan-Tilt-Zoom Cameras:
a. Provide Spectra Series, as manufactured by Pelco.
b. Or equal.
2. For Fixed Cameras:
a. Provide, as manufactured by Pelco
b. Or equal.

2.3 DIGITAL VIDEO RECORDER

A. DVR/Multiplexer:
1. Input Voltage: 120 VAC, 60Hz.
2. Signal System: NTSC.
3. Video Inputs: Analog video inputs 8.
4. Maximum IP and Analog cameras: 24
5. VGA Outputs: 1.
6. Connections: BNC (video), 6-pin mini-DIN (mouse and keyboard), DB15 (monitor port), RJ-45 (Ethernet), USB, miniature male phone plug.
7. Operating Temperature: 50 to 95 degrees Fahrenheit.
8. Storage Space: 4 TB.
9. Manufacturer and Model: DX8108-4000 digital video recorder as manufactured by Pelco, or equal.

B. Flat Panel Monitor:
1. Input Voltage: 120VAC, 60 Hz (power cord supplied).

2. Input/Output Signal: 1 Vp-p composite video signal, 75 ohms.
3. Connectors: BNC, 15-pin PC input, RCA, 4-pin mini DIN, HDMI/DVI
4. Type: 42" wide screen monitor.
5. Operating Temperature: 50 to 104 degrees Fahrenheit.
6. Operating Humidity: 20% to 85% non-condensing.
   Manufacturer: Pelco

C. Video Monitoring Computer:
   1. Relocate the existing surveillance PC to the PT/GAC control room. Coordinate with Owner.

2.4 SACM CENTRAL DATABASE COMPUTER

A. Use existing Central Database Computer. The new system shall be fully compatible with the existing Central Database Computer.

2.5 CARD ACCESS CONTROLLER

A. The controller shall be "Model DSX-1048PKG", as manufactured by DSX Access Systems, Inc, without exception to match Owner's existing system. The controller shall meet the following minimum requirements:
   1. Features:
      a. UL 294.
      b. Complete distributed processing: Never any reliance on host PC for any decision-making.
      c. Access verifications for all cards performed at controller.
      d. Linking: Input to Input, Input to Output, Output to Input, Output to Output, Code to Input and Code to Output Linking. Done locally at controller AND/OR controller to controller.
      e. Status LED for each Input.
      f. Status LED for each Output
      g. Controller Polled LED.
      h. Separate communication received and transmitted LEDs.
      i. Processor functioning properly LED.
      j. Dynamic Battery load test: Programmable using a spare open collector output to trip the Battery Test Input. Battery test may also be manually initiated through PC at any time.
      k. Battery Load shed circuit: Once the system is running on battery power the batteries must be disconnected at approximately 9VDC. The batteries must stay disconnected until AC power is restored.
      l. Controller can report to PC; loss of DC power, and low battery as separate alarms.
      m. Status LED for DC power to Controller.
      n. Real time on board clock/calendar generation that is synchronized with host PC clock/calendar.
      o. Dynamic memory allocation.

p. Change to/from auto buffering of all transactions based on communications status.
q. Point to point RS-485 4 wire controller communications allowing up to 4000 feet between each 1048PKG.
r. Wiring Management System that includes wire chases, cable ties and mounting clips.
s. Silkscreen detailing displays wiring termination and function of all terminals on controller.
t. Controller operating system resides in Flash ROM that is upgradeable thru the Host PC. Upgrades in controller operating system shall NOT require PROM changes.

2. Power Supplies: DSX-1040PDP (power distribution panel) and DSX1040CDM (communications distribution module), Included in 1042PKG.
   a. 2VDC 8A power for controllers. (Battery backed up).
   b. 12VDC 8.5A / 24VDC 4.25A power for locks (provide four (4) batteries "12V-BATT" for each controller package furnished and provide "Controller Power Source" AS-150" in power distribution panel).
   c. 5VDC .375 amp for 5 volt devices.
   d. UL294
   e. AC loss and low battery supervisory outputs.
   f. Battery load test control input.
   g. Lock power override input.
   h. Provides individual fused output for 8 locks.
   i. Provides for 8 individual sets of termination of Lock wiring and control relay wiring with removable terminals.
3. Controller Architecture: AM186 20 MHz processor, RAM, ROM, and removable field wiring terminals.
4. Compatibility: Controller is compatible with any identification device that transmits data using Wiegand, clock/data, or RS-232 ACSII at 1200-baud, 8N1. This includes but is not limited to proximity, barium ferrite, bar code, magnetic stripe, Wiegand, keypads, and biometric readers.
5. Memory: RAM: 512K and ROM: 512K Flash
6. Communications:
   a. Via direct serial port, dial-up modem, or TCP/IP. TCP/IP communications require additional hardware.
   b. Communication Ports: PC to controller 1 - RS-232 in; 50 feet max. 50ft 4000 feet requires two MCI modules.
   c. Controller to controller in the same enclosure; RS232 via the 1040CDM. 1042 PKG to 1048 PKG to 1022 regenerative RS485 4000 feet max via the 1040CDM.
   d. 1040CDM (communications distribution module) handles RS232 between controllers in the same enclosure, and serves as RS485 connection point for other 1040 series PKG units or 1022 controllers in controller network.
7. Operating Temperature: 32 to 131 degrees F. Operating Humidity: 0-95% RD.
8. Battery Changing Output: Trickle Charge: 13.5 VDC. 500ma, fused. Standby

Time: 11 hours under minimum load and 3.25 hours under maximum load w/ 2-12VDC 7AH battery.

9. Model DSX-1048PKG Intelligent 8 Door I/O Controllers. The controller shall be designed for eight-door reader/key pad application. Inputs shall include 32 EOL supervised inputs; each capable of 2, 3, or 4 state point monitoring with trouble reports. Outputs shall include 8 relay, 8-Open collector outputs, 8 pre-warn, 24 LED drivers as follows:
   a. 8 - Form C, 5 amp rated relay outputs.
   b. 8 - Open collector outputs 100ma.
   c. 8 - Pre-warn outputs for door being held open sounders.
   d. 24 - LED output Drivers to show lock status and or valid card read status at the reader or keypad.
10. The controller shall include trouble LEDs to show low battery, battery fuse, auxiliary power fuse, 12 VDC fuse, 5 VDC fuse, low AC, and High AC. Power supply shall be 12 VDC 1 amp and 5 VDC 300 milliamp.

2.6 PROXIMITY CARD READER

A. The access control readers shall be "Proxpro Proximity card reader" as manufactured by HID Corporation, without exception. The card reader shall read the encoded data from the access card and transmit the data back to the host panel, giving audible and visual indication of a properly read card. The card reader shall be listed under UL 294 as an access control system unit accessory. The reader shall have a lifetime warranty.

B. The card reader shall have a typical read range of 2 inches to 3 inches when used with an HID Corporation "IsoProx II" proximity card. The card reader shall be no larger than 3.135 inches by 1.720 inches. The card reader shall be a single unit with a two-piece housing, with an epoxy-potted enclosure and a snap-on cover, and with properly sized mounting holes that allow it to be attached to a standard mullion. The card reader shall be fully weatherized and shall have an operating temperature of -22 degrees Fahrenheit to 150 degrees Fahrenheit and shall have an operating humidity of 5 to 95 percent non-condensing. The card reader shall be made from polycarbonate material, and shall be gray or black.

C. The card reader shall have separate terminal control points for the green LED, the red LED, and the audible indicator. The card reader shall have a hold line that will buffer a card read until the panel has asserted that the information can be sent up line. The card reader shall have a card present line that will indicate that card data is ready to send for clock and data applications. The card reader shall have a re-present mode in which the card must be taken from the reader for one second before being read again.

D. The card reader shall communicate in a Wiegand protocol interface and be compatible with all standard access control systems. The voltage requirements of the card reader shall be 5 to 16 VDC. The card reader shall transmit at a 125 kHz frequency. Cable requirements of the card reader shall be 22 AWG twisted pair, shielded, stranded cable. The card reader shall be provided with a 10 wire pigtail

connector.

E. The card reader shall have the following reader configuration options:
   1. Reader beeps and flashes green on a card read, LED normally red, single line control of LED.
   2. Reader flashes green on a card read, LED normally red, single line controls of LED.
   3. Reader beeps on a card read, LED normally red, single line control of LED.
   4. Beeper and LED are controlled by host only, LED normally red, single line control of LED.
   5. Reader beeps and flashes green on a card read, LED normally off, red and green LED's controlled individually.
   6. Reader flashes green on a card read, LED normally off, red and green LED's controlled individually.
   7. Reader beeps on a card read, LED normally off, red and green LED's controlled individually.
   8. Beeper and LED are controlled by host only, LED normally off, red and green LED controlled individually.

F. TAMPER SWITCHES
   1. Enclosures, cabinets, housings, and boxes having hinged doors or removable covers and which contain connections of the system or power supplies, shall be provided with cover operated, corrosion-resistant tamper switches, arranged to initiate an alarm signal when the door or cover is moved. The enclosure and the tamper switch shall function together and shall not allow direct line of sight to any internal components before the switch activates. Tamper switches shall be inaccessible until the switch is activated; have mounting hardware concealed so that the location of the switch cannot be observed from the exterior of the enclosure; be connected to circuits which are under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating; shall be spring-loaded and held in the closed position by the door or cover; and shall be wired so that they break the circuit when the door or cover is disturbed.

2.7 CABLE

A. Supplier shall provide all necessary cables and conduits as specified in Div 16.

2.8 LOCK POWER SUPPLY

A. General: Provide power supplies for all locks.
   1. Features:
      a. UL Listed for Access Control Systems, (UL294).
      b. MEA approved.
      c. Input 115 VAC 50/60Hz, 1.9 amps.
      d. Ten amps continuous supply current at 24 VDC.

e. 24 VDC operation.
f. Power Supply Input: One common power input.
g. Eight Access Control System trigger inputs.
h. Eight independently controlled outputs.
i. Eight auxiliary power outputs (unswitched).
j. Output fuses are rated 3.5 amp.
k. Main fuse is rated at ten amp.
l. Battery fail and battery presence supervision (form "C" contact).
m. Unit is complete with enclosure, cam lock, transformer and battery leads.
n. Enclosure Dimensions: 15.5-inches (H) by 12-inches (W) by 4.5-inches (D).

B. Products and Manufacturers: Provide one of the following:
1. Model AL1024ULACM, by Altronix.
2. Or equal.

2.9 AUTOMATIC REQUEST TO EXIT SENSORS

A. General: The Request-to-Exit Sensors shall have a wrap around coverage pattern to ensure that no matter what direction a person approaches the door, the detector will see them and release the door. Provide an additional momentary manual request to exit pushbutton alongside the door should the sensor fail.
1. Features:
a. Single and Double-Door Use as shown.
b. Mounted: Wall or Ceiling as shown.
c. Internal vertical point-ability.
d. Up to 60 Second Adjustable Latch Time.
e. Selectable Relay Trigger Mode.
f. Selectable Fail-Safe / Fail-Secure.
g. 24 VAC or VDC Operation.
h. Automatic Integrated Sounder.
i. UL Listed.

B. Products and Manufacturers: Provide one of the following:
1. Model DS160, by Detection Systems Inc.
2. Or equal.

2.10 POWER SUPPLY

A. General: The Power Supply shall be provide for each camera with a 24VAC output and shall be mounted near to the Camera as shown on the Contract Drawing.

B. Specification:
1. Input Voltage: 120VAC/50Hz.
2. Output Voltage: 24VDC.
3. Current Rating:1A
4. Enclosure: NEMA4X, Aluminum, Weatherproof.

5. Input/Output Connectors: Screw-type barrier strips.
6. Circuit Breaker Rating: 4A.
7. Operating Temperature:-45 Deg C to 50 Deg C.

C. Products and Manufacturers: Provide one of the following
1. Model: WCS1-4, Pelco.
2. Or Equal.

2.11 LAN COMMUNICATION INTERFACE

A. General: The DSX-LAN (M) module connects the Master Access Controller to other components or the Communication Server PC over a Local or Wide Area Network. The WinDSX software is inherently TCP/IP capable and can redirect communication, that normally be transmitted out a serial port, over a LAN/WAN to a particular IP address.

B. Specification:
1. Auto-sensing 10/100Base-T/Auto-Duplexing.
2. RS-232/RS485 Controller Communication.
3. Static or Dynamic Communication Server IP.
4. Power:12VDC@300mA.
5. Network Protocol: TCP/IP.
6. Configured through serial port.
7. Password Protected programming.

C. Products and Manufacturers: Provide one of the following
1. DSC-LAN (M), DSX Access System.

2.12 DOORS STRIKE

A. General: Electric strikes for steel doors shall be compatible for use with rim exit devices (crash bar). Electric strikes shall be provided with fail secure feature. Lock power supply shall be provided for all electric strikes

B. Specification:
1. Stainless steel construction.
2. Field selectable fail safe/fail secure
3. Internally mounted solenoid.
4. Tamper resistant.
5. Endurance 500,000 cycles.
6. Voltage: 24VDC.

C. Accessories: Supplier shall provide necessary accessories for complete installation as shown on the Contract drawing.

D. Products and Manufacturers: Provide one of the following:

1. HES 9500,
2. Or Equal.

2.13 DOOR CONTACTS

A. General: Door contacts shall be provided flush-mounted

B. Features: The contact contains a hermetically sealed magnetic reed switch. The reed shall be potted in the contact housing with a polyurethane based compound. Contact and magnet housing shall snap-lock into a 15/16-inch diameter hole. Housings shall be molded of flame retardant ABS plastic. Color of housings shall be off-white. The magnet shall be made of Alnico V. Rare Earth Magnet shall be made of neodymium iron boron.

C. Products and Manufacturers: Provide one of the following:
   1. Model 1076W, by Sentrol.
   2. Or Equal.

2.14 INTERCOM

A. General: Provide outdoor intercom in locations shown on drawings. Construction shall be weather and vandal resistant and suitable for year round outdoor use. Intercom shall be able to dial any local plant telephone number and engage in two-way conversation utilizing built in handset.

B. Minimum Requirements:
   1. Intercom shall include dial pad, with call button to initiate dialing, and a handset.
   2. Intercom shall interfere with existing plant telephone exchange.
   3. LED light to indicate when intercom is “in use.”
   4. Adjustable volume for microphone and speaker.
   5. Disconnect on busy, return to dial tone, CPC, silence time out and maximum call time out.
   6. Power: telephone line powered 20V DC/20mA minimum.

C. Manufacturer:
   1. Viking.

2.15 COPPER TO FIBER CONVERTERS

A. General: Fiber transceivers (both transmitters and receivers) shall be provided as shown and shall convert intercom signal to a format suitable for use over fiber optic network. Mount in Security Interface Panels as shown.

B. Specifications:
   1. Connections for Speaker Output, Call Button and Gate Open Relay.

2. Remote Station (Entrance Gate) shall have Push to Call; Audio In/Out and relay contacts.
3. Master Station (Control Room) shall have Audio In/Out; Contact Closure; To Remove and From Remote contacts.
4. Audio shall be 3W (8-20 ohms).
5. Relay Contact shall be 0.5A.
6. Output shall be ST multimode Fiber (850/1310 nm).
7. Internal Circuit Board shall be IPC Standard.

C. Products and Manufacturer:
1. IFS VIC5211 series, by GE Security.
2. Or Equal.

2.16 NOT USED

2.17 SPARE PARTS

A. Supplier shall furnish and deliver the spare parts as outlined below, all of which shall be identical and interchangeable with similar parts furnished under this specification.

B. The following shall constitute the minimum spare parts:
1. Two CCTV cameras with zoom lens.
2. Two pan and tilt drive units.
3. Two fiber to copper converters.
4. Two SACM card readers.
5. One SACM card access controller.
6. One power supply for each type provided.

C. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the OWNER at the conclusion of the Project.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR shall examine the conditions under which the Work is to be installed and notify the ENGINEER, in writing, of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Installation:
1. Install in conformance with the requirements of National Electrical Code.

2. Install all security equipment at the locations as shown and in accordance with the manufacturer's recommendations.
3. Supplier shall ensure that adequate strain relief is provided in the installation of cameras to prevent premature damage to cables caused by continual flexing in pan/tilt applications.
4. The CCTV and SACM Systems shall be installed and wired completely by CONTRACTOR, as shown, who shall utilize the services of a manufacturer-trained and authorized Security System Supplier.
5. Supplier to be responsible for complete programming of CCTV system to include system application programming, camera presets, camera and sequencing.
6. Grounding: Ground all CCTV components and power supplies in accordance with NEC requirements.
7. The Supplier shall be responsible for providing and installing all conduits, wire cables, and all signal lines required to complete the installation of the access control systems. All on-site signal lines shall be in conduit.
8. Most of the conduit and wire for the access control system is shown on the drawings. The omission from the Drawings of any wire, conduit, cable or other signal lines does not relieve the Electrical CONTRACTOR from the responsibility of installing a complete and operable system.
9. The access control system and accessory equipment shall be installed in accordance with the manufacturer's instructions. The locations of equipment, alarms and similar devices shown on the Drawings are approximate only. Exact locations shall be as defined by the Engineer during construction. Obtain in the field all information relevant to the placing of equipment, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an acceptable manner.
10. Installation shall be in strict compliance with manufacture's standard detail, wiring diagrams and written instruction.
11. All work shall be executed in full accordance with applicable codes. Should any work be performed contrary to said codes and/or regulations, the CONTRACTOR shall be responsible for such violations and assume all costs arising as a result.
12. Brackets and hangers required for mounting of equipment shall be provided. They shall be installed in a workmanlike manner and not interfere with any other equipment.
13. The shields on instrumentation signal wires shall be continuous from source to destination. In no case shall more than one ground point be employed for each shield.
14. Do not splice or tap wiring except at device terminals or terminal blocks.

3.3 CLEANING

A. All instruments and equipment shall be left free from shipping stickers, paint, splatter, dirt, grease, etc., and shall be clean and in working condition at final acceptance. Touch-up paint shall be furnished as needed to repair blemishes and

scratches in finish pain on panels and enclosures, which shall be corrected by the CONTRACTOR.

3.4 FIELD TESTING

A. After installation of the equipment, controls and all appurtenances, CONTRACTOR shall field test the equipment for system operation and conformance to the specified performance parameters.

B. The CONTRACTOR shall perform pre-delivery testing, site testing, and adjustment of the completed access control system. The CONTRACTOR shall provide personnel, equipment, instrumentation, and supplies necessary to perform testing. Written notification of planned testing shall be given to the Owner at least 14 days prior to the test; notice shall not be given until after the CONTRACTOR has received written approval of the specific test procedures.

C. Test procedures shall explain in detail, step-by-step actions and expected results, demonstrating compliance with the requirements specified. Test reports shall be used to document results of the tests. Reports shall be delivered to the OWNER within 7 days after completion of each test.

D. Communications tests shall include:
   1. Controllers to manager server.
   2. Manager server to client.
   3. Remote dial-up support.

E. CONTRACTOR, under the observation of the ENGINEER, shall provide the services of factory-trained technicians to perform the following:
   1. Check and approve the installation of all components of the CCTV monitoring system and all cable connections between various components prior to placing the components into operation.
   2. Conduct a complete system checkout and adjust cameras, check operational functions of all of the equipment supplied under this Contract. All problems encountered shall be promptly corrected to prevent any delays in start-up.
      a. Check full range of travel for camera pan and tilt as well as speed of travel.
      b. Check shall be executed from system controller and shall include tilt up and down, pan right and left and preset.
      c. Check full range of lens function, including iris open, close, focus far, near,zoom telephoto and wide angle.
   3. CONTRACTOR shall provide all test equipment necessary to perform the testing during system checkout and testing.
   4. CONTRACTOR shall be responsible for initial system operation and shall make any changes, adjustments or replacements of any or all components, within the warranty period, if required, until the equipment supplied performs satisfactorily as intended.

5. CONTRACTOR shall furnish to the ENGINEER certified copies of set-up and adjustment reports for all specified devices.
6. CONTRACTOR shall furnish the ENGINEER an installation and inspection report certifying that all equipment has been installed correctly and is operating properly. The report shall be signed by the authorized representatives of CONTRACTOR and the system supplier.

3.5 MANUFACTURER'S FIELD SERVICES

A. CONTRACTOR shall arrange with the equipment manufacturer to provide direct supervision of all final connections between equipment and the wiring system.

B. CONTRACTOR shall furnish the services of a qualified manufacturer's service representative to assist in the installation of security system equipment, check the installation before it is placed into operation, assist in the performance of field tests, observe and assist initial operations and train the plant operations and maintenance staff in the care, operation and maintenance of the equipment.

C. Reports: CONTRACTOR shall submit a report from the manufacturer of each visit to the Site. CONTRACTOR shall provide complete information on time, schedule, tasks performed, persons contacted, problems corrected, test results, training, instruction, and all other pertinent information.

D. The Security System Supplier shall advise the OWNER of a local authorized distributor of the equipment supplied which stocks standard replacement parts. Supplier shall provide authorized distributor's name, address, telephone number and fax number to the OWNER.

E. Service shall be provided by a factory-trained and certified manufacturer's representative and shall maintain all equipment furnished under this Section.

F. Service provided shall include the following:
   1. Quarterly Service: Service intervals shall be quarterly consisting of three days of eight on-site hours for each quarterly service. Prior to the visits, the Supplier shall contact the OWNER and inquire as to problems encountered with the security system. Service visits shall be scheduled at times agreeable to the OWNER at least one week in advance. The quarterly service shall include, but is not limited to, the following:
      a. Provide manufacturer's recommended maintenance.
      b. Inspect all security system devices provided under this Section for proper operation and functionality.
      c. Perform necessary cleaning and service that is scheduled on a quarterly basis in accordance with the approved Operations and Maintenance Manual. Provide all expendable materials as necessary.
      d. Review and provide recommendations concerning OWNER'S operations.
      e. Replace or repair any defective security system device listed under this Section that is determined to be a result of an equipment malfunction or

failure. The cause of failure shall be jointly agreed upon by OWNER, CONTRACTOR, and ENGINEER.

f. Provide a detail field report to the OWNER and ENGINEER.

2. Technical Support: Technical support shall be provided between the hours of 7 AM and 3 PM, Monday through Friday when requested by the OWNER. Technical support shall include, but not limited to, the following:
   a. Telephone Technical Support: At a minimum, four calls of one hour each monthly.
3. CONTRACTOR shall include in the lump sum bid, 40 hours of service per year after the acceptance by the OWNER of any piece of equipment furnished under this Section to be provided by the security system supplier for emergency repair as directed by the ENGINEER, in writing.

+ + END OF SECTION + +

SECTION 14600

HOISTS AND CRANES, GENERAL

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. The CONTRACTOR shall furnish, install, and place in satisfactory operation the hoisting equipment and appurtenances complete with all necessary safety equipment, in accordance with the requirements of the Contract Documents.
   2. The CONTRACTOR shall furnish and install the tracks, ancillary steel, and appurtenances necessary for all monorail hoists and bridge cranes shown.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the Hoists and Cranes, General.

C. Related Sections:

   1. Section 05120, Structural Steel.
   2. Section 09910, Painting.
   3. Section 16220, Motors.

1.2 REFERENCES

A. Standard References in This Section:
   1. Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings (AISC).
   2. American Gear Manufacturers Association (AGMA).
   3. Overhead and Bridge Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist) (ANSI B30.2).
   4. Slings (ANSI B30.9).
   5. Hooks (ANSI B30.10)
   6. Overhead Hoists (NSI B30.16).
   7. Below - the - Hook Lifting Devices (ANSI B30.20).
   8. Specifications for Top Running Bridge Crane and Monorail Systems (CMAA 70).
   9. Specification for Structural Steel (ASTM A 36).
   10. California Code of Regulations, Title 8, Div. 1, Chapter 4, Subchapter7, Group 13 (CCR).

11. Crane Manufacturer's Association of America (CMAA).
12. National Electrical Manufacturers Association (NEMA)

1.3 SUBMITTALS

A. Qualifications Data:
   1. The Contractor shall submit all the required written certifications from Manufacturer showing that the equipment is in compliance with all applicable codes and standards.

B. Shop Drawings:
   1. The CONTRACTOR shall submit complete shop drawings of all hoist and crane equipment in accordance with the General Requirements. Such shop drawings shall include all electrical requirements, weights, wheel loads, dimensions, and clearances required.
   2. At the time of submission, the Contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

C. Closeout Submittals:
   1. The CONTRACTOR shall furnish to the ENGINEER [10] copies of complete operating and maintenance instructions of all the hoist and crane systems as specified in the TECHNICAL MANUALS of the General Requirements.

1.4 WARRANTY

A. General Warranty:
   1. The guaranty period shall be set forth in specification Section 00710, "General Conditions". In the event that the manufacturers guarantee period exceeds that as stated in the General Conditions, the manufacturers guarantee period will stay in effect and shall not be replaced by the previously stated.

1.5 MAINTENANCE

A. Spare Parts:
   1. Tools and Spare Parts: The CONTRACTOR shall supply one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment. All tools shall be of best quality and furnished in labeled tool boxes of suitable design.
   2. Each piece of equipment shall be furnished with one year's supply of lubricants, as well as spare parts as recommended by the manufacturer, such as bearings, drive belts, seals, washers, rings, and any other parts subject to wear or frequent replacement. All parts shall be properly labeled

and identified with the name and number of the equipment to which they belong.

3. Two radio remote controls shall be provided with monorail.

PART 2 – PRODUCTS

2.1 SYSTEM PERFORMANCE

A. System Description:
   1. The CONTRACTOR shall furnish and install all hoist and crane equipment specified below. Equipment of similar design shall be from the same manufacturer.
   2. The capacity of each hoist and trolley shall be permanently marked in a conspicuous manner on the equipment. The wire rope reeving shall be of the two-part double, cross mounted or similar appropriate type, to provide a true, vertical lift without drift, unless otherwise specified.
   3. All hooks shall be safety type with latch.
   4. The CONTRACTOR shall verify all dimensions and clearances in the field prior to erection and shall be responsible for the proper fitting and operation of the equipment.

2.2 MANUFACTURERS

A. Hoist and Cranes:
   1. Manufacturer: Provide product of one of the following:
      a. Harrington Hoists and Cranes
      b. Approved Equal

B. Radio Remote Controls:
   1. Products and Manufacturer:
      Provide one of the following:
      a. F24 Series as manufactured by Telecrane
      b. Approved Equal

2.3 MATERIALS

A. General:
   1. All materials used must be new and of the best commercial grade. Where materials are not specified, the CONTRACTOR shall have the manufacturer use the most suitable selection for the given application and environment.

2.4 DETAILS OF CONSTRUACTION

A. General:

1. All fabrication, assembly, and welding shall be carried out by factory-trained specialists and certified welders.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Hoists and Cranes
   1. All hoist and crane equipment shall be installed in strict accordance with the manufacturer's printed instructions and the CONTRACTOR shall arrange to have all installation performed under the guidance of the manufacturer's field representative.
   2. Care shall be taken, that the structural integrity of beams, columns, walls, floors, and roofs will be maintained at all times.

3.2 FIELD QUALITY CONTROL

A. Site Tests:
   1. After completion of the WORK, the CONTRACTOR shall test all hoist and crane equipment in the presence of the manufacturer's field representative, who shall certify in writing that the equipment meets all applicable standards and specifications.

++ END OF SECTION ++

SECTION 14605

ELECTRIC MONORAIL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. The CONTRACTOR shall furnish and install an electric monorail system complete, in accordance with the requirements of the Contract Documents. The hoist shall be of the low headroom type, equipped for electric lift and travel, and it shall fit a standard I-beam.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the Electric Monorail Systems.

C. Related Sections:
   1. Section 14600, Hoists and Cranes, General.

1.2 REFERENCES

A. Conform with References subsection as specified in Section 14600 Hoists and Cranes, General.

1.3 QUALITY ASSURANCE

A. Conform with Quality Assurance subsection as specified in Section 14600 Hoists and Cranes, General.

1.4 SUBMITTALS

A. Conform with Submittals subsection as specified in Section 14600 Hoists and Cranes, General.

B. At the time of submission, the Contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

1.5 WARRANTY

A. General Warranty:
   1. Conform with Warranty subsection as specified in Section 14600 Hoists and Cranes, General.

PART 2 –PRODUCTS

2.1 SYSTEM PERFORMANCE

A. System Description
   1. The monorail hoist shall be controlled from a radio remote control and be furnished complete with all required safety devices and overload protection.
   2. The power supply shall be from enclosed, UL-approved conductor bar systems. This festoon control shall be 14 GA stainless steel. Festoon support trolleys to be stainless steel construction cross arms to clamp to track with FC-TMC-U-SS clamps.
   3. The rail shall be a standard I-beam with end stops, securely anchored to the structure.
   4. Site Conditions:
      a. Location - PT/GAC Building
      b. Atmosphere - Chlorine Gas/Indoors

B. Design Criteria:
   1. The monorail system shall have the following capacities and dimensions.
      a. Hoist - Single speed, rope-type, for parallel lug mounting from a geared trolley, with upper and lower limit switches to prevent over travel, (automatic reset type).
      b. Gear - Fully enclosed, oil lubricated spur gear.
      c. Drum - Steel, with machine-cut grooves and flanges, to accommodate entire cable in one layer.
      d. Bearings - Anti-friction type, lifetime pre-lubricated and sealed.
      e. Motor and Drum Shaft - Grease lubricated, with ball or roller bearings.
      f. Brakes - Mechanical load brake and separate electric motor brake, each adjustable and capable of supporting the full load.

g.	Load Block	-	Heavy-duty with ball bearing sheave and forged steel swivel hook with anti-friction bearings and safety spring latch.
h.	Motor	-	Totally-enclosed, single speed.
i.	Trolley	-	Motor-driven, with 4 wheels, spur gear, magnetic brake, ball or roller bearings.
j.	Harrington Model No.	-	NERM020LD-SD
k.	Capacity (tons)	-	2
l.	Max Lift (feet)	-	25'
m.	Length of Rail (feet)	-	144'
n.	Lifting Speed (fpm)	-	15/5
o.	Travel Speed (fpm)	-	80/20
p.	Hoist Motor (hp)	-	2.4/0.8
q.	Trolley Motor (hp)	-	0.4/0.1
r.	Power Supply (V-ph-Hz)	-	480-3-60

2. Controls:
   a. Control equipment shall be mounted in an enclosed compartment which forms an integral part of the hoist and shall include a transformer for a 120-volt control circuit. Two radio remote controls with pushbuttons shall be provided.
   b. Each pushbutton shall be clearly marked to indicate its function and sufficient buttons shall be provided to control operations of hoists and trolley.
3. End Stops:
   a. The monorail shall be provided with bumpers capable of stopping the crane (not including the lifted load) at a rate of deceleration not to exceed 3 fps when traveling in either direction at 20 percent of rated speed. The bumpers shall have sufficient energy absorbing capacity to stop the crane when traveling at a speed of at least 40 percent of the rated load speed.

C. Painting
   1. The entire monorail system shall be shop coated in accordance with the Section 09910, “Painting”.

2.2 MANUFACTURERS

A. Monorail:
   1. Manufacturer: Provide product of one of the following:
      a. Harrington Hoist and Cranes.
      b. Approved Equal.

B. Radio Remote Control:
   1. Product and Manufacturer: Provide one of the following:
      a. F24 Series, as manufactured by Telecrane.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. All monorail equipment shall be installed in strict accordance with the manufacturer's published or written instructions.

++ END OF SECTION ++

SECTION 14610

JIB CRANE

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install hoisting equipment complete and operational.

B. Equipment covered under this specification is identified as follows:
   1. GAC Backwash Supply Pumps Jib Crane.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following except as otherwise shown of specified.
   1. American Institute of Steel Construction (AISC).
   2. American National Standards Institute (ANSI) B30 Code.
   3. American Welding Society (AWS).
   4. Hoist Manufacturers Institute (HMI).
   5. Monorail Manufacturers Association (MMA).
   6. Occupational Safety and Health Act (OSHA).
   7. American Gear Manufacturers Association (AGMA).

B. Field Measurements:
   1. Take field measurements prior to preparation of Shop Drawings and fabrication where required, to ensure proper fitting of the work.

C. Experience:
   1. Manufacturer shall have a minimum of five years of experience of producing substantially similar equipment, and shall be able to show evidence of at least twenty installations in satisfactory operation for at least five years in the continental United States.

1.3 PERFORMANCE

A. Load Capacity:
   1. All load-bearing parts shall be designed with a safety factor of at least five at rated capacity loads, based on the ultimate strength of the materials used.
   2. Hoisting equipment shall be able to safely handle a load equal to 125 percent of

the rated capacity.

1.4 SUBMITTALS

A. Submit for approval complete detailed shop drawings and descriptions of the proposed equipment in accordance with Section 01330, Submittal Procedures, including but not limited to:
   1. Manufacturer's literature, illustrations, specifications and engineering data.
   2. Manufacturer's Installation Recommendations and Instructions for each type of hoisting equipment assembly.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Insofar as is practical, the equipment specified herein shall be factory assembled into components as large as may be practically shipped to minimize field assembly requirements. Parts and assemblies that are shipped unassembled shall be packaged and tagged in a manner that will protect the equipment from damage and facilitate the final assembly in the field.

B. Materials and equipment shall be boxed, crated or otherwise completely enclosed and protected during shipment, handling, and storage. Generally, unpainted machined parts shall be protected from damage by the elements with the application of a strippable protective coating. Boxes, packaging or other such protection shall be clearly labeled with manufacturer's name, brand or model designation, and description.

C. Inspect all boxes, crates and packages upon their delivery to the site. Protect materials and equipment from exposure to the elements and keep dry at all times. Handle and store to prevent damage in accordance with manufacturer's recommendations. Any lost items shall be replaced. Material and equipment damaged by handling and storage shall be repaired or replaced as directed by the Engineer.

D. Store materials in accordance with requirements of Section 01661, Storage and Protection of Products, unless more stringent requirements are required by the manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL:

A. The hoisting equipment shall be completely assembled, painted, tested, and adjusted in the shop as far as practical before shipment.

B. The equipment shall operate within the space shown with the minimum clearance to the nearest obstruction no less than three inches vertical and two inches horizontal.

C. Jib Crane:
   1. Provide bronze bearings of the precision ball, roller, or washer type, conforming to the requirements of the Anti-Friction Bearing Manufacturers Association (AFBMA). Bearings shall be designed for a minimum B-10 bearing life of 5,000 hours.
   2. Bearing housings shall be split or designed to permit easy removal of the shafts. Bearings shall be pre-lubricated and sealed for the life of the bearings, or have accessible grease fittings for proper means of lubrication.
   3. All connections shall be bolted.
   4. The boom shall be constructed of a standard I-beam with trolley stops located at both ends.

D. Hoists:
   1. All hoisting equipment shall be provided with brakes for constant load control in lifting operations.

2.2 PRODUCT AND MANUFACTURER:

A. Provide equipment manufactured by one of the following:
   1. Spanco, Model 301 Wall Bracket Tie Rod Supported Jib Crane.
   2. Gorbel, Model WB100-G1-8-6 Wall Bracket Jib Crane.
   3. Or Equal.

2.3 SURFACE PREPARATION AND PAINTING:

A. Provide surface preparation, priming and finish painting in shop in accordance with Section 09910, Painting.

B. Field touch-up painting shall conform to Section 09910, Painting.

C. Gears, bearing surfaces, and similar mechanical, polished and non-ferrous surfaces shall receive a heavy application of a corrosion-resistant coating which shall be maintained during storage and until the equipment is placed in operation.

D. Legible load-capacity charts shall be provided for each hoisting equipment unit, showing rated capacity in all permitted working positions and configurations of use. Charts shall be provided in a permanent, weather resistant format, and shall be mounted on or attached to the hoisting equipment in a prominent manner, without interfering with the function of the equipment.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Hoisting equipment shall be installed complete and operational in accordance with manufacturer's recommendations and the Contract Documents.

B. The hoisting equipment manufacturer's representative shall instruct the Contractor on the required adjustments, test all components, and furnish the manufacturer's certificates.

C. Lubricants: Install products recommended by the equipment manufacturer for initial operation.

D. Provide trolley stops on both ends of the monorail.

E. Inspection:
   1. Verify for each installation that equipment:
      a. Is in full compliance with the Contract Documents.
      b. Is properly installed, adjusted, and ready for service.
      c. Is free of defects.

3.2 TESTING ADJUSTING AND BALANCING:

A. Demonstrate for each installation that equipment:
   1. Is in full compliance with the Contract Documents.
   2. Is properly installed, adjusted, and ready for service.
   3. Is free of defects.
   4. Performs satisfactorily under normal operating conditions, as directed by the Engineer.

B. Load Testing:
   1. Test function of each crane under loads of 100 percent and 125 percent of the rated capacity.
   2. Test function of hoisting equipment brakes at 100 percent of the rated load capacity.

C. Submit reports of field test results and inspections.

D. Any defects that become apparent or develop during the testing shall be corrected at no additional expense to the owner.

3.3 SCHEDULE:

A. GAC Backwash Supply Pumps:
   1. Provide one Jib Crane: 1/2 ton capacity; 8 ft span; 10 ft minimum under

boom height; 12 ft maximum overall height.

2. Provide one geared trolley, operator, and chain wheel.
3. Provide one electric chain hoist 1/2 ton capacity, with 12 feet of galvanized chain.

+++ END OF SECTION +++

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SECTION 14630

BRIDGE CRANES

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. The CONTRACTOR shall furnish and install an electrically operated bridge crane system complete, in accordance with the requirements of the Contract Documents. The bridge crane shall be of the low headroom type, equipped for electric lift and travel in both directions and it shall be mounted as indicated on the Drawings.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the Bridge Cranes.

C. Related Sections:
   1. Section 14600, Hoists and Cranes, General.

1.2 REFERENCES

A. Conform with References subsection as specified in Section 14600 Hoists and Cranes, General.

1.3 QUALITY ASSURANCE

A. Confirm with Quality Assurance subsection as specified in Section 14600 "Hoists and Cranes, General."

1.4 SUBMITTALS

A. Conform with Submittals subsection as specified in Section 14600 Hoists and Cranes, General.

B. At the time of submission, the Contractor shall in writing, call the Engineer's attention to any deviations that the Drawings may vary from the requirements of the Engineer's Specifications. Comply with the requirements of Section 01330.

1.5 WARRANTY

A. Conform with Warranty subsection as specified in Section 14600 Hoists and Cranes, General.

PART 2 -PRODUCTS

2.1 SYSTEM PERFORMANCE

A. System Description:
   1. The bridge crane system shall be controlled from a pendant pushbutton station and be furnished complete with all required safety devices and overload protection.
   2. The power supply shall be from enclosed, UL-approved conductor bar systems.
   3. The rails shall be standard I-beams, or specially fabricated steel sections, firmly anchored to the structure, as shown.
   4. The track deflection shall not exceed 1/800 of the span, or 1-1/4 inches, whichever is less.
   5. The completed crane system, including the tracks, shall be the product of one crane manufacturer regularly engaged in the manufacture of such equipment.
   6. Site Conditions:

a.	Location	-	GAC Feed Pump Station
b.	Atmosphere	-	Indoors

B. Design Criteria:
   1. The bridge crane system shall have the following capacities and dimensions:

a	Harrington Model No.	-	TMS-3-0335/N ERMO30CD-SD
b.	Type of Crane	-	Top Running
c.	Type of Bridge	-	Single Beam
d.	Capacity (tons)	-	3
e.	Maximum lift (feet)	-	14
f.	Length of track (feet)	-	35
g.	Span between tracks (feet)	-	26’-6”
h.	Speed Control	-	Multiple Speed
i.	Lifting Speed (fpm)	-	17/3 Dual Speed
j.	Trolley Speed (fpm)	-	80/13 Dual Speed
k.	Bridge Speed (fpm)	-	8-80 Variable Speed
l.	Hoist Motor (hp)	-	4.7
m.	Trolley Motor (hp)	-	0.54
n.	Bridge Motor (hp)	-	0.33 (2)
o.	Power Supply (V-ph-Hz)	-	480-3-60

2.2 MANUFACTURERS

A. Bridge Crane:
   1. Manufacturer: Provide product of one of the following:
      a. Harrington Hoist and Cranes.
      b. Approved Equal.

2.3 DETAILS OF CONSTRUCTION

A. Hook and Wire Rope:
   1. The lifting hook shall be of drop-forged, heat-treated steel with a 360-degree swivel on a shielded roller thrust bearing with safety spring latch.
   2. The wire ropes shall be improved plow steel with steel center complete with swaged fittings.

B. Hoist and Drive:
   1. The hoisting drum shall be a large diameter, deep grooved and flanged drum with at least 2 full turns of rope to remain on the drum at the lowest hook position, with heavy- duty, pre-lubricated sealed bearings.
   2. The drum shall be driven by a helical gear reducer with external spur drum gear enclosed in an oil-tight housing.
   3. The housing motor shall be a standard, 30-minute duty-motor, 1750 rpm, with suitable NEMA type shaft extension.
   4. The hoisting mechanism shall be provided with dc magnet-actuated disc motor brake with hook drift.
   5. The motor shall be rated with minimum of 150 percent of full load torque, with gravity type upper and lower hook limit switch, and an overload cut off switch to interrupt the raising circuit.

C. Trolley Assembly:
   1. The trolley assembly shall be a top-running type, as specified, framed by a structural shape welded into a stable assembly for proper wheel and bearing alignment.
   2. The trolley assembly shall be supported by trolley wheels of tread surfaces hardened to 375 to 425 Brinell.
   3. The tread shall be tapered to provide suitable running alignment for trolley.
   4. Each wheel shall be supported on tapered roller bearings suitable to take radial and thrust loads.
   5. The wheel mounting shall be designed so that axles and wheels can be removed without disturbing other truck elements of their alignment.
   6. The wheel tread shall be smooth, true, and uniform within 0.010-inch tread diameter on all wheels.
   7. The trolley shall be driven by a 30-minute-duty-cycle rated motor, through an oil-tight gear reducer conforming with NEMA Specifications.
   8. The motor shall be provided with cushion start and controller for smooth travel and load control.

9. The driver shall provide synchronous drive from gear reducer to both drive wheels.
10. The trolley drive shall be provided with integrally mounted spring set and an electrically- released drag brake.

D. Crane Bridge Assembly:
1. The crane bridge assembly shall be a single beam over-riding electrically driven, center-drive type.
2. The bridge beam shall be designed in accordance with the latest specifications of the Crane Manufacturers Association of America.
3. It shall be fabricated of standard structural shape per AISC Specifications.
4. At full load, the beam shall be designed to limit the deflection to 1/600 of the span, but not to exceed 1-1/4-inch maximum deflection.
5. An ASCE rail shall be provided on top of the beam securely fastened in place to maintain center distance.
6. Provision shall be made to prevent creeping of bridge rails by means of positive stops at the ends of the rails.
7. Crane shall be reinforced with outrigger to provide squareness with end truck, adequate lateral stiffness with a minimum lateral moment of inertia of 1/20 that of the vertical beam moment of inertia.
8. Outrigger shall furnish support for squaring shaft and the crane drive motor and gear reducer assembly.

E. End Trucks:
1. The end trucks shall be traversed by stable assembly of structural shapes welded together to provide proper wheel and bearing alignment.
2. The end truck wheel base shall be a minimum of 1/7 of the crane span.
3. One wheel of each end truck shall be geared and meshed with the pinion mounted on the crane squaring shaft.
4. The crane and trucks shall contain diaphragm members welded to truck frames to maintain alignment and distribute truck loads on inner and outer truck members.
5. The truck shall be designed so that, in case of a wheel axle or wheel failure, the drop of the load will be limited to one inch.
6. The end trucks shall be fastened to the bridge beams with bolts to ensure alignment in assembly.

F. Crane Wheels:
1. Crane wheels shall have tread surfaces hardened to 375 to 425 Brinell.
2. Treads shall be tapered to provide suitable running alignment for crane.
3. Each wheel shall be supported on tapered roller bearings mounted on stationary axles, suitable to take radial and thrust loads.
4. The wheels shall be lubricated at the factory with a sodium base grease, and provided with a suitable reservoir of lubricant to eliminate the need for field lubrication.
5. Wheel axles must have mounting nuts for bearing adjustment.

6. Wheel mounting shall be designed so that axles and wheels can be removed without disturbing other truck elements of their alignment.
7. Wheel treads shall be smooth, true, and uniform within 0.01-inch tread diameter on all wheels.

G. Crane Drive:
1. The crane drive motor shall be totally enclosed, 30-minute cycle rated.
2. The motor shall be integral with a fully enclosed oil splash lubricated gear reduction.
3. The motor, the drive shaft, and the gear reduction shafts shall be supported by permanently lubricated precision ball or roller bearings.
4. The drive shaft shall provide synchronous drive from the gear reduction to both end trucks.
5. The crane drive shall include integrally-mounted spring set electrically released dc rectified disc brake.

H. Drive Shaft:
1. The drive shaft of the crane shall be supported on lubricated, precision, ball-bearing pillow blocks based on 10-ft maximum centers.
2. These pillow blocks shall be lubricated through pressure grease fittings.
3. The crane drive shaft shall be steel and designed to limit torsional shaft stress to 6,000 psi.
4. Maximum torsional twist angle in the drive shaft shall not exceed one degree of the wheel rotation under maximum rated load, regardless of load location.

I. Bearing Life:
1. All bearings in the crane wheels, those supporting the drive shafts, and the gear reduction shafts, shall be designed for 5,000 hrs B-10 bearing life minimum.

J. Gearing:
1. All gears shall be cut from solid blanks with 20-degree pressure angle involute shape for high strength and shall comply with AGMA specifications for load ratings.
2. All gears operating at higher than 20 fpm pitch line speed shall be fully enclosed in oil-tight housings and lubricated by splash principle.
3. All gear teeth shall have ductile cores and be surface hardened to RC40 minimum.
4. The gear shall provide for a minimum service of 4,000 hr, compounded for intermittent operations corresponding to 5 years minimum industrial use.

K. Bridge Stops:
1. The bridge shall be provided with bumpers capable of stopping the crane (not including the lifted load) at a rate of deceleration not to exceed 3 fps when traveling in either direction at 20 percent of rated speed.

2. The bumpers shall have sufficient energy absorbing capacity to stop the crane when traveling at a speed of at least 40 percent of the rated load speed.
3. Bridge trucks shall be equipped with sweeps which extend below the top of the rail and project in front of the crane wheel.

L. Runway Beams and Rails:
1. The runway beams and rails shall be furnished as specified or shown.
2. The rails shall be an ASCE type securely fastened into the runway beams.
3. The runway beams shall be designed from an ASTM A36 structural steel shape and shall have a maximum deflection not to exceed 1/800 of the span.
4. The beams shall be equipped with stops on both ends capable of withstanding the impact of the fully loaded crane at 50 percent of rated speed, and shall be field-adjustable.
5. All necessary column supports or clamps, hanger rods, bolts, and fittings shall be provided.

M. Electrical Controls:
1. Electrical controls shall be single-speed or multiple-speed as required in each equipment specification.
2. Bridge control shall include a mainline magnetic contactor, manually-operated fused mainline disconnect with lock-out provisions, branch circuit fuses, reversing bridge control, and transformer with fused secondary.
3. Bridge control shall be mounted on bridge in NEMA 12 enclosure actuated from a pendant pushbutton station suspended from movable trolley hoist 4 ft above operating floor.
4. Motors shall be provided with cushion start.

N. Conductor and Wirings:
1. The runway shall be provided with enclosed conductor base electrification adequately supported.
2. The bridge shall have a rigid truck festoon type electrification.
3. All other wiring of the crane shall be in rigid or flexible conduit and in accordance with National Electrical Code and complying with Fire Underwriters specifications.
4. When a crane is shipped knocked down, the wiring shall terminate in approved terminal boxes and the wire end shall be provided with permanent marking tags.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General
1. All bridge crane equipment shall be installed in strict conformance with the manufacturer's published or written instructions. Cranes shall be factory

assembled and given a no-load test. All major components of the system shall be marked at the factory to assure prompt and correct field identification.

B. Painting
   1. The entire crane assembly shall be shop coated in accordance with the Section 09910,"Painting."

3.2 FIELD QUALITY CONTROL

A. Site Tests
   1. After completion of the WORK, the CONTRACTOR shall test all hoist and crane equipment in the presence of the manufacturer's field representative, who shall certify, in writing, that the equipment meets all applicable standards and specifications.

++ END OF SECTION ++

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SECTION 15051

BURIED PIPING INSTALLATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to install and test all buried piping, fittings, and specials. The Work includes the following:
      a. All types and sizes of buried piping, except where buried piping installations are specified under other Sections.
      b. Unless otherwise shown or specified, this Section includes all buried piping Work required, beginning at the outside face of structures or structure foundations, including piping beneath structures, and extending away from structures.
      c. Work on or affecting existing buried piping.
      d. Installation of all jointing and gasket materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, cathodic protection, and other Work required for a complete, buried piping installation.
      e. Supports, restraints, and thrust blocks.
      f. Pipe encasements, with the exception of piping embedded in concrete within a structure or foundation specified under Section 15052, Exposed Piping Installation.
      g. Field quality control, including testing.
      h. Cleaning and disinfecting.
      i. Incorporation of valves, meters, and special items shown or specified into piping systems in accordance with the Contract Documents and as required.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before buried piping Work.
   2. Coordinate with appropriate piping Sections of Division 15, Mechanical.

C. Related Sections:
   1. Section 02300, Earthwork.
   2. Section 02318, Crushed Stone and Gravel.
   3. Section 02505, Pipe Embedment and Backfill Materials
   4. Section 03300, Cast-In-Place Concrete.

5. Section 09910, Painting.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ASME Boiler and Pressure Vessel Code.
   2. ASME B31.3, Process Piping.
   3. American Society for Non-Destructive Testing (ASNT), ASNT-TC-1A, Recommended Practice, Personnel Qualification, and Certification in Non-destructive Testing.
   4. ASTM B32, Specification for Solder Metal.
   5. ASTM C924, Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Test Method.
   6. ASTM D2321, Practice for Underground Installation of Thermoplastic Pipe for Sewers and other Gravity-Flow Applications.
   7. ASTM D2774, Practice for Underground Installation of Thermoplastic Pressure Piping.
   8. ASTM F1417, Test Method for Installation Acceptance of Plastic Gravity Sewer Lines using Low-Pressure Air.
   9. ANSI/AWWA C105, Polyethylene Encasement for Ductile-Iron Pipe Systems.
   10. ANSI/AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   11. ANSI/AWWA C206, Field Welding of Steel Water Pipe.
   12. ANSI/AWWA C600, Installation of Ductile-Iron Water Mains and Their Appurtenances.
   13. ANSI/AWWA C605, Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.
   14. ANSI/AWWA C606, Grooved and Shouldered Joints.
   15. ANSI/AWWA C651, Disinfecting Water Mains.
   16. AWWA M9, Concrete Pressure Pipe.
   17. AWWA M23, PVC Pipe - Design and Installation.
   18. AWWA M41, Ductile-Iron Pipe and Fittings.
   19. AWWA M55, PE Pipe - Design and Installation.
   20. ASCE 37, Design and Construction of Sanitary and Storm Sewers.
   21. American Concrete Pipe Association, Concrete Pipe Handbook.
   22. NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with requirements and recommendations of authorities having jurisdiction over the Work, including.

2. Obtain required permits for Work in roads, rights-of-way, railroads, and other areas of the Work. Also, obtain permits as required by local, state and federal agencies for discharging water for excavations.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Laying schedules for concrete pipe and piping with restrained joints.
      b. Details of piping, specials, joints, harnessing and thrust blocks, and connections to piping, structures, equipment, and appurtenances.
   2. Product Data: Manufacturer's literature and specifications, as applicable, for products specified in this Section.
   3. Testing Procedures: Submit proposed testing procedures, methods, apparatus, and sequencing. Obtain ENGINEER's approval prior to commencing testing.

B. Informational Submittals: Submit the following:
   1. Certifications: Certificate signed by manufacturer of each product certifying that product conforms to applicable referenced standards.
   2. Field Quality Control Submittals: Results of each specified field quality control test.

C. Closeout Submittals: Submit the following:
   1. Record Documentation:
      a. Maintain accurate and up-to-date record documents showing modifications made in the field, in accordance with approved submittals, and other Contract modifications relative to buried piping Work. Submittal shall show actual location of all piping Work and appurtenances at same scale as the Drawings.
      b. Show piping with elevations referenced to Project datum and dimensions from permanent structures. For each horizontal bend in piping, include dimensions to at least three permanent structures, when possible. For straight runs of piping provide offset dimensions as required to document piping location.
      c. Include profile drawings with buried piping record documents when the Contract Documents include piping profile drawings.
      d. Conform to Section 01782, Record Documents.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery:
   1. Deliver materials to the Site to ensure uninterrupted progress of the Work.

2. Upon delivery inspect pipe and appurtenances for cracking, gouging, chipping, denting, and other damage and immediately remove from Site and replace with acceptable material.

B. Storage:
   1. Store materials to allow convenient access for inspection and identification. Store material off ground using pallets, platforms, or other supports. Protect packaged materials from corrosion and deterioration.
   2. Pipe and fittings other than PVC and CPVC may be stored outdoors without cover. Cover PVC and CPVC pipe and fittings stored outdoors.

C. Handling:
   1. Handle pipe, fittings, specials, and accessories carefully in accordance with pipe manufacturer's recommendations. Do not drop or roll material off trucks. Do not drop, roll or skid piping.
   2. Avoid unnecessary handling of pipe.
   3. Keep pipe interiors free from dirt and foreign matter.
   4. Protect interior linings and exterior coatings of pipe and fittings from damage. Replace pipe and fittings with damaged lining regardless of cause of damage.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Piping materials are specified in the Buried Piping Schedule at end of this Section. Piping materials shall conform to Specifications for each type of pipe and piping appurtenances in applicable Sections of Division 15, Mechanical.

B. General:
   1. Pipe Markings:
      a. Factory-mark each length of pipe and each fitting with designation conforming to those on approved laying schedules.
      b. Manufacturer shall cast or paint on each length of pipe and each fitting pipe material, diameter, and pressure or thickness class.

C. Polyethylene Encasement:
   1. Polyethylene may be supplied in tubes.
   2. Polyethylene shall be blue in color.
   3. Polyethylene encasement materials shall be in accordance with ANSI/AWWA C105.

D. Tracing Wire:
   1. Tracking wire shall be installed on all water pipe.

2.2 BURIED PIPING IDENTIFICATION

A. Polyethylene Underground Warning Tape for Metallic Pipelines:
   1. Tracer tape shall be of inert, acid- and alkali-resistant, polyethylene, four mils thick, six inches wide, suitable for direct burial. Tape shall be capable of stretching to twice its original length.
   2. Message shall read, "CAUTION [insert customized name of pipe service, i.e., "POTABLE WATER", "SANITARY SEWER", "CHLORINE GAS", or other service as appropriate, as indicated in the Buried Pipe Schedule at the end of this Section] PIPE BURIED BELOW", with bold letters approximately two inches high. Messages shall be printed at maximum intervals of two feet. Tape shall be custom colored the same as pipeline colors specified for associated pipe service in Section 09910, Painting.
   3. Manufacturer: Provide products of one of the following:
      a. Brady Corporation
      b. Seton Identification Products
      c. Marking Services, Inc.
      d. Or equal.

B. Detectable Underground Warning Tape for Non-Metallic Pipelines:
   1. Tape shall be of inert, acid- and alkali-resistant, polyethylene, five mils thick, six inches wide, with aluminum backing, and have 15,000 psi tensile strength and 80 percent elongation capability. Tape shall be suitable for direct burial.
   2. Message shall read, "CAUTION [insert customized name of pipe service, i.e., "POTABLE WATER", "SANITARY SEWER", "CHLORINE GAS", or other appropriate service, as indicated in the Buried Pipe Schedule at the end of this Section] PIPE BURIED BELOW" with bold letters approximately two inches high. Messages shall be printed at maximum intervals of two feet. Tape shall be custom colored the same as the pipeline colors as specified for the associated pipe service in Section 09900, Painting.
   3. Manufacturer: Provide products of one of the following:
      a. Brady Corporation
      b. Seton Identification Products
      c. Marking Services, Inc.
      d. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Install piping as shown, specified, and as recommended by pipe and fittings manufacturer.
   2. In event of conflict between manufacturer's recommendations and the Contract Documents, request interpretation from ENGINEER before proceeding.
   3. ENGINEER will observe excavations and bedding prior to laying pipe by CONTRACTOR. Notify ENGINEER in advance of excavating, bedding, pipe laying, and backfilling operations.
   4. Minimum cover over buried piping shall be three feet, unless otherwise shown or approved by ENGINEER.
   5. Earthwork is specified in Section 02300, Earthwork.
   6. Excavation in excess of that required or shown, and that is not authorized by ENGINEER shall be filled at CONTRACTOR's expense with granular material furnished, placed, and compacted in accordance with Section 02318, Crushed Stone and Gravel.
   7. Comply with NFPA 24 for "Outside Protection", where applicable to water piping systems used for fire protection.
   8. CONTRACTOR shall confirm the pipe class and flange pattern of existing pipe and valves that are to be connected to or reinstalled prior to ordering proposed pipe.

B. Manufacturer's Installation Specialist:
   1. Provide services of competent installation specialist of pipe manufacturer when pipe installation commences for:
      a. Concrete pipe.
      b. FRP pipe.
      c. Thermoplastic pipe.
   2. Retain installation specialist at the Site for minimum of two days (eight hours per day at the Site) or until competency of pipe installation crew has been satisfactorily demonstrated.

C. Separation of Sewers and Potable Water Piping:
   1. Horizontal Separation:
      a. Where possible, existing and proposed potable water mains and service lines, and sanitary, combined, and storm sewers shall be separated horizontally by clear distance of at least ten feet.
      b. If local conditions preclude the specified clear horizontal separation, installation will be allowed if potable water main is in separate trench or

on undistributed earth shelf on one side of sewer and with bottom of potable water main at least 18 inches above top of sewer.

c. Exception:

1) Where it is not possible to provide minimum horizontal separation described above, construct potable water main of cement-lined ductile iron pipe with restrained push-on joint or restrained mechanical joint pipe complying with public water supply design standards of authority having jurisdiction. Hydrostatically test water main and sewer as specified in this Section prior to backfilling. Hydrostatic test pressure at crossing shall be at least 150 psi.

2. Vertical Separation:

a. Provide minimum vertical distance of 18 inches between outside of potable water main and outside of sewer when sewer crosses over potable water main.

b. Center a section of potable water main pipe at least 17.5 feet long over sewer so that sewer joints are equidistant from potable water main joints.

c. Provide adequate structural support where potable water main crosses under sewer. At minimum, provide compacted select backfill for ten feet on each side of crossing.

d. Exceptions:

1) Where it is not possible to provide minimum vertical separation described above, construct potable water main of cement-lined ductile iron pipe with restrained push-on joint or restrained mechanical joint pipe. Hydrostatically test water main and sewer as specified in this Section, prior to backfilling. Hydrostatic test pressure at crossing shall be at least 150 psi.

2) Encase either potable water main or sewer in watertight carrier pipe extending ten feet on each side of crossing, measured perpendicular to potable water main.

D. Plugs:

1. Temporarily plug installed pipe at end of each day of work or other interruption of pipe installation to prevent entry of animals, liquids, and persons into pipe, and entrance or insertion of deleterious materials into pipe.

2. Install standard plugs in bells at dead ends, tees, and crosses. Cap spigot and plain ends.

3. Fully secure and block plugs, caps, and bulkheads installed for testing to withstand specified test pressure.

4. Where plugging is required for phasing of the Work or subsequent connection of piping, install watertight, permanent type plugs, caps, or bulkhead acceptable to ENGINEER.

E. Bedding Pipe: Bed pipe as specified and in accordance with details on the Drawings.

1. Trench excavation and backfill, and bedding materials shall conform to Sections 02300, Earthwork and 02505, Pipe Embedment and Backfill Materials, as applicable.
2. Where ENGINEER deems existing bedding material unsuitable, remove and replace existing bedding with approved granular material furnished, placed, and compacted in accordance with Section 02318, Crushed Stone and Gravel. Payment for additional excavation and providing granular material will be made under the unit price payment items in the Contract.
3. Where pipe is installed in rock excavation, provide minimum of three inches of granular bedding material underneath pipe smaller than four-inch nominal diameter, and minimum of six inches of granular bedding material underneath pipes four-inch nominal diameter and larger.
4. Excavate trenches below bottom of pipe by amount shown and indicated in the Contract Documents. Remove loose and unsuitable material from bottom of trench.
5. Carefully and thoroughly compact pipe bedding with hand held pneumatic compactors.
6. Do not lay pipe until ENGINEER approves bedding condition.
7. Do not bring pipe into position until preceding length of pipe has been bedded and secured in its final position.

F. Laying Pipe:
   1. Conform to manufacturer's instructions and requirements of standards and manuals listed below, as applicable:
      a. Ductile Iron Pipe: ANSI/AWWA C600, ANSI/AWWA C105, AWWA M41.
      b. Concrete Pipe: AWWA M9.
      c. Thermoplastic Pipe: ASTM D2321, ASTM D2774, ANSI/AWWA C605, AWWA M23, AWWA M45, AWWA, M55.
      d. Sanitary and Storm Sewers: ASCE 37.
   2. Install pipe accurately to line and grade shown and indicated in the Contract Documents, unless otherwise approved by ENGINEER. Remove and reinstall pipes that are not installed correctly.
   3. Slope piping uniformly between elevations shown.
   4. Keep groundwater level in trench at least 6 inches below bottom of pipe before laying pipe. Do not lay pipe in water. Maintain dry trench conditions until jointing and backfilling are complete. Keep clean and protect interiors of pipe, fittings, valves, and appurtenances.
   5. Start laying pipe at lowest point and proceed towards higher elevations, unless otherwise approved by ENGINEER.
   6. Place bell and spigot-type pipe so that bells face the direction of laying, unless otherwise approved by ENGINEER.
   7. Place concrete pipe containing elliptical reinforcement with minor axis of reinforcement in vertical position.

8. Excavate around joints in bedding and lay pipe so that pipe barrel bears uniformly on trench bottom.
9. Deflections at joints shall not exceed 75 percent of amount allowed by pipe manufacturer, unless otherwise approved by ENGINEER.
10. For PVC and CPVC piping with solvent welded joints, 2.5-nch diameter and smaller, and copper tubing, snake piping in trench to compensate for thermal expansion and contraction.
11. Carefully examine pipe, fittings, valves, and specials for cracks, damage, and other defects while suspended above trench before installation. Immediately remove defective materials from the Site and replace with acceptable products.
12. Inspect interior of all pipe, fittings, valves, and specials and completely remove all dirt, gravel, sand, debris, and other foreign material from pipe interior and joint recesses before pipe and appurtenances are moved into excavation. Bell and spigot-type mating surfaces shall be thoroughly wire brushed, and wiped clean and dry immediately before pipe is laid.
13. Field cut pipe, where required, with machine specially designed for cutting the type of pipe being installed. Make cuts carefully, without damage to pipe, coating or lining, and with smooth end at right angles to axis of pipe. Cut ends on push-on joint type pipe shall be tapered and sharp edges filed off smooth. Do not flame-cut pipe.
14. Do not place blocking under pipe, unless specifically approved by ENGINEER for special conditions.
15. Touch up protective coatings in manner satisfactory to ENGINEER prior to backfilling.
16. Notify ENGINEER in advance of backfilling operations.
17. On steep slopes, take measures acceptable to ENGINEER to prevent movement of pipe during installation.
18. Thrust Restraint: Where required, provide thrust restraint conforming to Article 3.3 of this Section.
19. Exercise care to avoid flotation when installing pipe in cast-in-place concrete, and in locations with high groundwater.

G. Polyethylene Encasement:
1. Provide polyethylene encasement for ductile iron piping and fittings to prevent contact between pipe, fittings, and surrounding bedding material and backfill.
2. All ductile iron pipe, fittings, valves and hydrant leads shall be polyethylene wrapped.
3. Polyethylene encasement wrap shall overlap each adjacent pipe a minimum of one foot. Polyethylene tape shall be used to secure the polyethylene encasement tubes to each other.
4. Polyethylene encasement wrap shall be provided and installed per the OWNER's 2009 standard drawing number 100-C.
5. Polyethylene encasement installation shall be in accordance with ANSI/AWWA C105.

H. Tracing Wire:
   1. Provide tracing wire shall be installed with all buried water pipe.
   2. Tracing wire shall be copper wire coated in PVC and shall be taped to the top of the pipe every five feet.
   3. The maximum tracing wire length without terminating in a curb stop box shall be 500'.
   4. Curb stop boxes shall not be located in paved areas.
   5. Splices shall be kept to a minimum and must be approved by the CONSTRUCTION CONTRACT ADMINISTRATOR.
   6. Tracing wire shall be provided and installed per the OWNER's 2009 standard drawing number 100-C.

I. Jointing Pipe:
   1. Ductile Iron Mechanical Joint Pipe:
      a. Immediately before making joint, wipe clean the socket, plain end, and adjacent areas. Taper cut ends and file off sharp edges to provide smooth surface.
      b. Lubricate plain ends and gasket with soapy water or manufacturer's recommended pipe lubricant, in accordance with ANSI/AWWA C111, just prior to slipping gasket onto plain end of the joint assembly.
      c. Place gland on plain end with lip extension toward the plain end, followed by gasket with narrow edge of gasket toward plain end.
      d. Insert plain end of pipe into socket and press gasket firmly and evenly into gasket recess. Keep joint straight during assembly.
      e. Push gland toward socket and center gland around pipe with gland lip against gasket.
      f. Insert bolts and hand-tighten nuts.
      g. If deflection is required, make deflection after joint assembly and prior to tightening bolts. Alternately tighten bolts approximately 180 degrees apart to seat gasket evenly. Bolt torque shall be as follows:

Pipe Diameter (inches)	**Bolt Diameter (inches)**	**Range of Torque (ft-lbs)**
3	5/8	45 to 60
4 to 24	3/4	75 to 90
30 to 36	1	100 to 120
42 to 48	1.25	120 to 150

      h. Bolts and nuts, except those of stainless steel, shall be coated with two coats, minimum dry film thickness of eight mils each, of high build solids epoxy or bituminous coating manufactured by Tnemec, or equal.
      i. Restrained mechanical joints shall be in accordance with Section 15061, Ductile Iron Pipe.

2. Ductile Iron Push-On Joint Pipe:
    a. Prior to assembling joints, thoroughly clean with wire brush the last eight inches of exterior surface of spigot and interior surface of bell, except where joints are lined or coated with a protective lining or coating.
    b. Wipe clean rubber gaskets and flex gaskets until resilient. Conform to manufacturer's instructions for procedures to ensure gasket resiliency when assembling joints in cold weather.
    c. Insert gasket into joint recess and smooth out entire circumference of gasket to remove bulges and to prevent interference with proper entry of spigot of entering pipe.
    d. Immediately prior to joint assembly, apply thin film of pipe manufacturer's recommended lubricant to surface of gasket that will come in contact with entering spigot end of pipe, or apply a thin film of lubricant to outside of spigot of entering pipe.
    e. For assembly, center spigot in pipe bell and push pipe forward until spigot just makes contact with rubber gasket. After gasket is compressed and before pipe is pushed or pulled in the rest of the way, carefully check gasket for proper position around the full circumference of joint. Final assembly shall be made by forcing spigot end of entering pipe past gasket until spigot makes contact with base of the bell. When more than a reasonable amount of force is required to assemble the joint, remove spigot end of pipe to verify proper positioning of gasket. Do not use gaskets that have been scored or otherwise damaged.
    f. Maintain an adequate supply of gaskets and joint lubricant at the Site when pipe jointing operations are in progress.
3. Ductile Iron Proprietary Joints:
    a. Install pipe that utilizes proprietary joints for restraint specified in Section 15061, Ductile Iron Pipe, or other such joints, in accordance with manufacturer's instructions.
4. Ductile Iron Flanged Joints:
    a. Assemble flanged joints using ring-type gaskets, thickness as recommended by pipe manufacturer but not less than 1/8-inch thick, for raised face flanges. Use full face gaskets for flat face flanges, unless otherwise approved by ENGINEER or recommended by pipe manufacturer. Gaskets shall be suitable for service intended in accordance with manufacturer's ratings and instructions. Gaskets shall be properly centered.
    b. Bolts shall be tightened as recommended by the manufacturer in sequence that ensures equal distribution of bolt loads.
    c. Length of bolts shall be uniform. Bolts shall not project beyond the nut more than 1/4-inch when fully tightened. Bolts shall not fall short of the nut when fully taken up. Ends of bolts shall be machine cut and neatly rounded. Do not use washers.
    d. Prior to assembly, lubricate bolt threads and gasket faces.

e. After assembly, coat all bolts and nuts, except those of stainless steel, with two coats, minimum dry film thickness of eight mils each, of high-build epoxy or bituminous coating manufactured by Tnemec, or equal.

5. Thermoplastic Pipe Joints:
   a. Solvent Cement Welded Joints:
      1) Bevel pipe ends and remove all burrs before making joints. Clean pipe and fittings thoroughly. Do not attempt to make solvent cement joints if temperature is below 40 degrees F. Do not make solvent cement welded joints in wet conditions.
      2) Use solvent cement supplied or recommended by pipe manufacturer.
      3) Apply joint primer and solvent cement and assemble joints in accordance with recommendations and instructions of manufacturer of joint materials and pipe manufacturer.
      4) Take appropriate safety precautions when using joint primers and solvent cements. Allow air to circulate freely through pipelines to allow solvent vapors to escape. Slowly admit water when flushing or filling pipelines to prevent compression of gases within pipes.
   b. Bell and Spigot Joints:
      1) Bevel pipe ends, remove all burrs, and provide a reference mark at correct distance from pipe end before making joints.
      2) Clean spigot end and bell thoroughly before making the joint. Insert O-ring gasket while ensuring that gasket is properly oriented. Lubricate spigot with manufacturer's recommended lubricant. Do not lubricate bell and O-ring. Insert spigot end of pipe carefully into bell until reference mark on spigot is flush with bell.
6. Runs shall contain unions at connection to equipment and at reasonable distances along the length of runs to permit convenient disassembly of piping and removal of equipment.
7. Copper Tubing Joints:
   a. Soldered Joints:
      1) Assemble copper tubing with soldered joints. Solder shall be 95-5 tin-antimony solder conforming to ASTM B32.
      2) Ream or file pipe to remove burrs.
      3) Clean and polish contact surfaces of joints.
      4) Apply flux to both male and female ends.
      5) Insert end of tube into full depth of fitting socket.
      6) Heat joint evenly.
      7) Form continuous solder bead around entire circumference of joint starting at the bottom.
8. Mechanical Coupling Joints:
   a. Mechanical couplings include: sleeve-type flexible couplings, split flexible couplings, ANSI/AWWA C606 grooved or shouldered end couplings, plasticized PVC couplings, and other mechanical couplings specified in Section 15120, Piping Specialties and Accessories.

b. Prior to installing and assembling mechanical couplings, thoroughly clean joint ends with wire brush to remove foreign matter.

c. For mechanical couplings that incorporate gaskets, after cleaning apply lubricant to rubber gasket or inside of coupling housing and to joint ends. After lubrication, install gasket around joint end of previously installed piece and mate joint end of subsequent piece to installed piece. Position gasket and place coupling housing around gasket and over grooved or shouldered joint ends. Insert bolts and install nuts tightly by hand. Tighten bolts uniformly to produce an equal pressure on all parts of housing. When housing clamps meet metal to metal, joint is complete and further tightening is not required.

d. For plasticized PVC couplings, loosen the stainless steel clamping bands and remove clamps from coupling. Slide coupling over plain ends of pipes to be joined without using lubricants. Place clamps over each end of coupling at grooved section and tighten with torque wrench to torque recommended by manufacturer.

9. HDPE Pipe Joints:

a. Bell and Spigot Joints:

1) Remove all burrs and provide reference mark at correct distance from pipe end. Place mark such that no more than 1/2-inch of machined spigot surface will be visible outside of bell after pipe has been joined.

2) Clean spigot end and bell thoroughly with soap and water before positioning gasket.

3) Lubricate spigot groove with manufacturer's recommended lubricant. Thoroughly clean gasket and place in spigot groove starting at bottom, ensuring that gasket fins face backwards toward pipe.

4) Thoroughly lubricate gasket with pipe manufacturer's recommended lubricant and equalize stretch in gasket by running screwdriver under gasket around its entire circumference three times. Reposition gasket in groove after stretching.

5) Thoroughly clean and lubricate receiving bell. Align pipe as straight as possible and insert spigot end of pipe carefully into bell until reference mark on spigot is flush with bell.

6) If mechanical means are used to insert spigot end, protect with wood the end of pipe being pushed, to ensure even distribution of pressure.

b. Butt Fusion Welded Joints:

1) Install joints in accordance with manufacturer's instructions using hydraulic butt fusion machine or manual machine equipped with torque wrench. Equipment shall be able to achieve and maintain heating tool temperature range of 400 to 450 degrees F and an interface pressure of 60 to 90 psi.

2) Clean interior and exterior of pipe and fitting ends with clean, dry, lint-free cloth.

3) Align ends to be joined in the fusion machine without forcing ends into

alignment. Adjust alignment as necessary and tighten clamps to prevent slippage.

4) Place facing tool between ends to be joined and face them to provide clean, smooth, parallel mating surface. If stops are present, face ends down to the stops. Remove all shavings after facing without touching ends.
5) Re-check alignment of ends and check for slippage against fusion pressure. There shall be no detectable gaps between ends. Align outside diameters.
6) Heating tool shall maintain pipe manufacture's recommended temperature range. Place the tool between ends to be joined. Move ends against heating tool to achieve full contact. Hold ends against heating tool without force until the following melt bead size is formed:

Pipe Diameter (inches)	Required Melt Bead Size (inches)
2 to 4	1/8 to 3/16
4 to 12	3/16 to 1/4
12 to 24	1/4 to 7/16
24 to 54	7/16 to 9/16

7) Upon forming proper melt bead size, quickly separate ends and remove heating tool. Quickly inspect melted ends and bring ends together applying joining force recommended by manufacturer, using 60 to 90 psi interfacial pressure to form double bead rolled over surface of pipe on both ends.
8) Hold joining force against ends until joint is cool to the touch. Cooling period shall be 30 to 90 seconds per inch of pipe diameter. Heavier wall thicknesses may require longer cooling times as recommended by pipe manufacturer.
9) Upon completing joint, inspect to verify double bead has been formed on both sides, uniformly rounded and consistent in size all around joint. Remove faulty joints and re-joint.

10. HDPE Double Containment Pipe (Containment and Carrier Pipe):
    a. Install joints of double containment piping system in accordance with pipe manufacturer's instructions. Joints shall be butt fusion welded.

J. Backfilling:
1. Conform to applicable requirements of Section 02300, Earthwork and Section 02505, Pipe Embedment and Backfill Materials.
2. Place backfill as Work progresses. Backfill by hand and use power tampers until pipe is covered by at least one foot of backfill.

K. Connections to Valves and Hydrants:
   1. Install valves and hydrants as shown and indicated in the Contract Documents.
   2. Provide suitable adapters when valves or hydrants and piping have different joint types.
   3. Provide thrust restraint at all hydrants and at valves located at pipeline terminations.

L. Transitions from One Type of Pipe to Another:
   1. Provide necessary adapters, specials, and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.

M. Closures:
   1. Provide closure pieces shown or required to complete the Work.

3.2 TRACER TAPE INSTALLATION

A. Polyethylene Underground Warning Tape for Metallic Pipelines:
   1. Provide polyethylene tracer tape for buried metallic piping, which includes pipe that is steel, ductile iron, cast iron, concrete, copper, and corrugated metal.
   2. Provide tracer tape 12 to 18 inches below finished grade, above and parallel to buried pipe.
   3. For pipelines buried eight feet or greater below finished grade, provide second line of magnetic tracer tape 2.5 feet above crown of buried pipe, aligned along pipe centerline.
   4. Tape shall be spread flat with message side up before backfilling.

B. Detectable Underground Warning Tape for Non-Metallic Pipelines:
   1. Provide polyethylene tracer tape with aluminum backing for buried, non-metallic piping, which includes pipe that is PVC, CPVC, polyethylene, HDPE, FRP, ABS, and vitrified clay.
   2. Provide magnetic tracer tape 12 to 18 inches below finished grade, above and parallel to buried pipe.
   3. For pipelines buried eight feet or greater below finished grade, provide second line of magnetic tracer tape 2.5 feet above crown of buried pipe, aligned along the pipe centerline.
   4. Tape shall be spread flat with message side up before backfilling.

3.3 THRUST RESTRAINT

A. Provide thrust restraint on pressure piping systems where shown or indicated in the Contract Documents.

B. Thrust restraint may be accomplished by using restrained pipe joints, concrete thrust

blocks, or harnessing buried pipe. Thrust restraints shall be designed for axial thrust exerted by test pressure specified in the Buried Piping Schedule at the end of this Section.

C. Place concrete thrust blocks against undisturbed soil. Where undisturbed soil does not exist, or for projects where the Site consists of backfill material, thrust restraint shall be provided by restrained pipe joints.

D. Restrained Pipe Joints:
   1. All buried pipe greater than four inches shall be restrained joint pipe.
   2. Pipe joints shall be restrained by means suitable for the type of pipe being installed.
      a. Ductile Iron, Push-on Joints and Mechanical Joints: Restrain with proprietary restrained joint system as specified in Section 15061, Ductile Iron Pipe; lugs and tie rods; or other joint restraint systems approved by ENGINEER.
      b. Where push-on type or other non-restrained joints are utilized, provide tie rods across joint or other suitable joint restraint system, subject to the approval of ENGINEER.
      c. Prestressed Concrete Cylinder Pipe shall be restrained utilizing bell-bolt, clamp type, or snap ring-type restrained joints.
      d. Harnessed lengths for buried pipe shall be determined by the pipe manufacturer in accordance with the formula for Determination of Buried Pipe Harnessed Lengths located in paragraph 3.7 of this Section.

E. Concrete Thrust Blocks:
   1. Provide concrete thrust blocks on pressure piping at changes in alignment of 15 degrees or more, at tees, plugs and caps, and where shown or indicated in the Contract Documents. Construct thrust blocks of Class B concrete, conforming to Section 03300, Cast-In-Place Concrete.
   2. Install thrust blocks against undisturbed soil. Place concrete so that pipe and fitting joints are accessible for repair.
   3. Concrete thrust block size shall be as shown on the Drawings or as approved by ENGINEER.

3.4 WORK AFFECTING EXISTING PIPING

A. Location of Existing Underground Facilities:
   1. Locations of existing Underground Facilities shown on the Drawings should be considered approximate.
   2. Determine the true location of existing Underground Facilities to which connections are to be made, crossed, and that could be disturbed, and determine location of Underground Facilities that could be disturbed during excavation and backfilling operations, or that may be affected by the Work.

B. Taking Existing Pipelines and Underground Facilities Out of Service:
   1. Conform to Section 01143, Coordination with OWNER's Operations.
   2. Do not take pipelines or Underground Facilities out of service unless specifically listed in Section 01143, Coordination with OWNER's Operations, or approved by ENGINEER.
   3. Notify ENGINEER in writing prior to taking pipeline or Underground Facilities out of service. Shutdown notification shall be provided in advance of the shutdown in accordance with the General Conditions and Section 01143, Coordination with OWNER's Operations.

C. Work on Existing Pipelines or Underground Facilities:
   1. Cut or tap piping or Underground Facilities as shown or required with machines specifically designed for cutting or tapping pipelines or Underground Facilities, as applicable.
   2. Install temporary plugs to prevent entry of mud, dirt, water, and debris into pipe.
   3. Provide necessary adapters, sleeves, fittings, pipe, and appurtenances required to complete the Work.
   4. Conform to applicable requirements of Section 01143, Coordination with OWNER's Operations, Section 01723, Cutting and Patching, and Section 01724, Connections to Existing Facilities.

3.5 FIELD QUALITY CONTROL

A. General:
   1. Test all piping, except as exempted in the Buried Piping Schedule in this Section.
   2. When authorities having jurisdiction are to witness tests, notify ENGINEER and authorities having jurisdiction in writing at least 48 hours in advance of testing.
   3. Conduct all tests in presence of ENGINEER.
   4. Remove or protect pipeline-mounted devices that could be damaged by testing.
   5. Provide all apparatus and services required for testing, including:
      a. Test pumps, compressors, hoses, calibrated gages, meters, test containers, valves, fittings, and temporary pumping systems required to maintain OWNER's operations.
      b. Temporary bulkheads, bracing, blocking, and thrust restraints.
   6. Provide air if an air test is required, power if pumping is required, and gases if gases are required.
   7. Unless otherwise specified, OWNER will provide fluid required for hydrostatic testing. CONTRACTOR shall provide means to convey fluid for hydrostatic testing into piping being tested. CONTRACTOR shall provide fluid for other types of testing required.

8. Repair observed leaks and repair pipe that fails to meet acceptance criteria. Retest after repair.
9. Unless otherwise specified, testing shall include existing piping systems that connect with new piping system. Test existing pipe to nearest valve. Piping not installed by CONTRACTOR and that fails the test shall be repaired upon authorization of OWNER. Unless otherwise included in the Work, repair of existing piping or Underground Facilities will be paid as extra Work.
10. When testing existing chlorine gas and sulfur dioxide gas systems to nearest isolation valve, provide a tee in the line adjacent to valve. Branch outlet on tee shall be provided with valve and used for cleaning, testing, draining, and drying the pipe. Unless otherwise indicated, existing chlorine or sulfur dioxide system shall not be shut down during testing or for installing tee and valve. Prior to placing pipeline in service, valve on branch outlet of tee shall be plugged or sealed with blind flange or threaded plug. Repair damage to system resulting from this Work at no extra cost to OWNER.

B. Test Schedule:
1. Refer to the Buried Piping Schedule in this Section for type of test required and required test pressure.
2. Unless otherwise specified, required test pressures are at lowest elevation of pipeline segment being tested.
3. For piping not listed in Buried Piping Schedule in this Section:
   a. Hydrostatically test pipe that will convey liquid at a pressure greater than five psig. Provide process air pipe test for pipe that will convey air or gas under pressure or vacuum, except chlorine gas, which requires separate test.
   b. Use exfiltration testing, low-pressure air testing, or vacuum testing for other piping.
   c. Disinfect for bacteriological testing piping that conveys potable water.
4. Test Pressure:
   a. Use test pressures listed in Buried Piping Schedule in this Section.
   b. If test pressure is not listed in Buried Piping Schedule, or if test is required for piping not listed in the Buried Piping Schedule, test pressure will be determined by ENGINEER based on maximum anticipated sustained operating pressure and methods described in applicable ANSI/AWWA manual or standard that applies to the piping system.

C. Hydrostatic Testing:
1. Preparation for Testing:
   a. For thermoplastic pipe and fiberglass pipe, follow procedures described in Section 7 of ANSI/AWWA Standard C605.
   b. For HDPE pipe, follow procedures described in ASTM F2164. Test duration, including time to pressurize, time for initial expansion, time at test pressure, and time to depressurize, shall not exceed eight hours. If re-

testing of a test section or pipeline is required, at least eight hours shall elapse between tests.

c. Prior to testing, ensure that adequate thrust protection is in place and joints are properly installed.

2. Test Procedure:
   a. Fill pipeline slowly to minimize air entrapment and surge pressures. Fill rate shall not exceed one foot of pipe length per second in pipe being tested.
   b. Expel air from pipe as required. Obtain approval of ENGINEER prior to tapping pipe for expelling air.
   c. Examine exposed joints and valves, and make repairs to eliminate visible leakage.
   d. After specified wetting period, add fluid as required to pressurize line to required test pressure. Maintain test pressure for a stabilization period of ten minutes before beginning test.
   e. HDPE Pipe: After filling pipeline, gradually pressurize pipe to test pressure and maintain required test pressure for three hours for pipe to expand. During expansion, add fluid to maintain required test pressure. Begin timed test period after expansion period and other requirements are met.
   f. Timed test period shall not begin until after pipe has been filled, exposed to required wetting period, air has been expelled, and pressure stabilized.
   g. Timed Test Period: After stabilization period, maintain test pressure for at least two hours. During timed testing period, add fluid as required to maintain pressure within five psig of required test pressure.
   h. Pump from test container to maintain test pressure. Measure volume of fluid pumped from test container and record on test report. Record pressure at test pump at 15 minute intervals for duration of test.

3. Allowable Leakage Rates: Leakage is defined as the quantity of fluid supplied to pipe segment being tested to maintain pressure within five psi of test pressure during timed test period. Allowable leakage rates for piping are:
   a. No Leakage: Pipe with flanged, welded, fused, threaded, soldered, or brazed joints.
   b. Rates based on formula or table in ANSI/AWWA Manual M41:
      1) Metal and fiberglass pipe joined with rubber gaskets as sealing members, including the following joint types:
         a) Bell and spigot and push-on joints.
         b) Mechanical joints.
         c) Bolted sleeve type couplings.
         d) Grooved and shouldered couplings.
   c. Rates based on make-up allowance in ANSI/AWWA Manual M9:
      1) Prestressed concrete cylinder pipe and other types of concrete pipe joined with O-ring rubber gasket sealing members.
   d. Rates based on formula or table in ANSI/AWWA C605:

1) Plastic pipe joined with O-ring gasket sealing members.

e. Rates based on formula or table in ANSI/AWWA C603:
   1) Asbestos-cement pipe.

D. Sewer Testing with Low Pressure Air:
   1. Plug and bulkhead ends and lateral connections of pipe segment to be tested.
   2. Required test pressure shall be increased by an amount equal to the elevation of groundwater above invert of lowest point of pipe segment being tested.
   3. Test in accordance with requirements of authority having jurisdiction.
   4. If there are no Laws and Regulations covering the test, use test procedures described in the following standards:
      a. Thermoplastic: ASTM F1417.
      b. Concrete Pipe: ASTM C924.

E. Vertical Deflection Test for Thermoplastic, FRP, and HDPE Pipe:
   1. A deflection test shall be performed on all gravity sanitary and storm sewers using flexible pipe. Conduct vertical deflection test at least thirty days after backfill has been placed.
   2. Use rigid ball or mandrel for deflection test, which shall have diameter of at least 95 percent of base inside diameter or average inside diameter of piping, depending on which is specified in applicable ASTM standard, including appendix, to which pipe is manufactured. Perform test without mechanical pulling devices. Re-install and retest pipe segments that exceed deflection of five percent. All tests must be witnessed and approved by a representative of OWNER.

F. Chlorine Piping:
   1. Scope: Applicable to chlorine gas piping and liquid chlorine piping systems that are under vacuum or positively pressurized.
   2. General:
      a. Complete testing includes pressure testing, drying, and air or nitrogen leak testing as specified, and service gas leak testing. Pressure-test system after cleaning.
      b. Complete testing prior to backfilling trench. Maintain groundwater level below bottom of trench until test is successfully completed.
      c. Relative to chlorine testing, the term “plastic piping” includes the following types of pipe: PVC, CPVC, ABS, FRP, polypropylene (PP), PTFE, PFA, PVDF, ethylene chlorotrifluoroethylene (ECTFE), and ethylene tetrafluoroethylene (ETFE).
      d. Do not attempt to repair leaks until pressure has dissipated from system.
      e. Repair and retest system until successful test is performed.
      f. When piping is filled with chlorine, take appropriate precautions relative to safety and minimizing potential for leaks.
   3. Evaporator-supplied Systems:

a. Disconnect vent from discharge side of pressure relief valve of each evaporator, plug resultant opening, inspect, and secure all joints, close valves that discharge to atmosphere, and open all inline valves. Open valve in bypass line around pressure reducing valve on downstream side of each evaporator to provide through-path around valve.
b. Test system as specified in this Section.
c. After testing, restore equipment, valves, and piping to pre-test positions and close inline valves. Reconnect vent line to downstream side of pressure relief valve of each evaporator and close valve in bypass line around pressure reducing valve on downstream side of each evaporator.

4. Pressure Testing:
   a. Fill pipe with water and hydrostatically test in accordance with Paragraph 3.5.C of this Section.
   b. Hydrostatic test pressure shall be in accordance with the Buried Piping Schedule in this Section. When hydrostatic test pressure is not specified in Buried Piping Schedule, for pressure piping use test pressure of 1.5 times maximum operating pressure to which system may be subjected. If not otherwise specified in the Buried Piping Schedule, hydrostatically test vacuum piping to at least 25 psig.
   c. After hydrostatic testing, replace all moisture absorbing gaskets and valve packing.
   d. Steel Pipe: If drying after hydrostatic testing is impractical or cannot be accomplished, test steel piping by either pneumatic testing or alternate testing (weld examination) in accordance with Chlorine Institute Pamphlet No. 6. When performing pneumatic test, implement precautions to safeguard personnel and minimize risk.

5. Drying:
   a. Dry out chlorine piping systems prior to placing in service. Drying is required for all piping regardless of whether water has been purposely introduced to system.
   b. Steel Pipe: Accomplish drying by passing steam through piping from high end of system until piping is heated to approximately 200 degrees F unless lower temperature is required to protect system from damage. While steaming, allow condensate and foreign matter to drain from pipe. Disconnect steam supply and drain pockets and low spots in pipe. While pipe is still warm, blow dry, oil-free air with dew point of -40 degrees F or below, or nitrogen, through pipe until exiting air dew point is equal to supply air dew point. Valves shall be at half-open position during drying. Valves removed temporarily from system during drying must be free of moisture before being re-installed.
   c. Plastic Pipe: Dry gas piping only. Drain and remove all water and moisture from system. After draining, “pig” the pipe to remove excess

water. Dry system with air or nitrogen in accordance with requirements for steel pipe, except that steam shall not be used on plastic pipe.

6. Air or Nitrogen Leak Testing:
   a. Do not leak-test plastic piping with nitrogen or air.
   b. Use nitrogen gas or oil-free dry air to test steel piping. Gradually introduce nitrogen or dry air and pressurize to 50 psig. Maintaining this pressure while testing all joints along pipe for leaks with soapy water solution. When system is free from leaks at this pressure, increase test pressure in increments of approximately 50 psig up to the lower of either 150 psig or 110 percent of maximum system operating pressure. After each increase in pressure, check for leaks using soapy water solution and implement corrective action as necessary.
   c. When system has no leaks at final test pressure, depressurize the system, disconnect the test source, and cap the system to prevent entrance of water.
   d. Nitrogen Gas: Use cylinders of dry, high-purity nitrogen gas, nitrogen handling cylinder mounted pressure regulator with zero to 300 psig range, and necessary fittings and adapters to connect source to pipe being tested. Pressure regulator shall be self-relieving type, venting to atmosphere, and include throttling valve.
   e. Dry Air: Provide oil-free air with relative humidity of zero. Fittings, adapters, and accessories, pressure regulator, and throttling valve shall be suitable for pressure testing with air and rated for 300 psig.
7. Service Gas (Chlorine Gas) Leak Testing:
   a. After pressure testing and immediately after chlorine system has been dried, gradually introduce service gas to pipe; service gas is gas that will be conveyed through pipe when pipe is in use. After gas has completely filled pipe, increase service gas pressure to five psig and check all joints for leaks.
   b. Implement precautions to safeguard personnel and minimize risk when performing service gas leak test.
   c. Use liquid ammonia solution or chlorine gas detector to check for chlorine leaks. When using liquid ammonia solution, spray solution at pipe joints and connections. Do not squirt liquid on pipe or fittings. Chorine gas and ammonia solution will react to produce a dense, white cloud. Leaks in piping and equipment, if detected, shall not be repaired until all gas has been purged from system being tested. Upon completion of repairs, repeat cleaning, drying, nitrogen or air leak testing, and service gas leak testing.
   d. Do not perform service gas leak testing on liquid chlorine piping.

G. Examination of Welds:
   1. Personnel performing examination of welds shall be qualified to at least Level II

in accordance with ASNT SNT-TC-1A.

2. Conform to ASME Boiler and Pressure Vessel Code Section V and applicable articles for examination of welds.
3. Visually examine all welds, Category D Fluid Service, in conformance with ASME B31.3.
4. Examine at least ten percent of welds using liquid penetrant examination.
5. If defect is detected, all welds shall be examined by liquid penetrant examination.
6. At conclusion of liquid penetrant examination, remove penetrant test materials by flushing, washing, or wiping clean with applicable solvents.

H. Bacteriological Testing:
   1. Bacteriological testing for potable water lines, finished water lines, and other piping in accordance with the Buried Piping Schedule, is specified in Article 3.6 of this Section.

3.6 CLEANING AND DISINFECTION

A. Cleaning, General: Clean pipe systems as follows:
   1. Thoroughly clean all piping, including flushing with water, dry air, or inert gas as required, in manner approved by ENGINEER, prior to placing in service. Flush chlorine solution and sodium hypochlorite piping with water.
   2. Piping 24-inch diameter and larger shall be inspected from inside and debris, dirt and foreign matter removed.
   3. For piping that requires disinfection and has not been kept clean during storage or installation, swab each section individually before installation with five percent sodium hypochlorite solution.

B. Cleaning of Gas and Air Piping:
   1. Unless otherwise specified, non-chlorine gas and air system piping six-inch diameter and smaller shall be blown out, using air or testing medium specified. Piping larger than six-inch diameter shall be cleaned by having a swab or “pig” drawn through each pipe reach.
   2. After connecting to equipment, blow out pipe using the equipment.
   3. Upon completion of cleaning, piping shall be drained and dried with blown air.

C. Cleaning of Chlorine Gas and Liquid Chlorine Systems:
   1. General: All portions of system shall be cleaned free of oil and grease.
   2. Clean chlorine piping in accordance with procedures in Chlorine Institute Pamphlet No. 6.
   3. Steel Pipe:
      a. Pipe threads shall be washed clean and free from cutting oil.

b. Remove from inside of pipe and fittings all pipe dope, oil, and grease by drawing cloth wetted with solvent through each pipe segment, or other method acceptable to ENGINEER.
c. Valves shall be dismantled, thoroughly cleaned with solvents, and repacked, if necessary, prior to installation.
d. Cap or plug openings in pipe at end of each workday.
e. When using solvents such as carbon tetrachloride or trichloroethylene, exercise caution to minimize solvent exposure, and provide proper handling and disposal. Do not use solvents containing hydrocarbons or alcohols.

4. Plastic Pipe: Clean vacuum and liquid piping with a detergent and water and thoroughly rinse to remove all detergent, after which cleaning ball or swab shall be drawn through pipe.

D. Disinfection:
1. Disinfect all potable and finished water piping.
2. Suggested procedure for accomplishing complete and satisfactory disinfection is specified below. Other procedures may be considered for acceptance by ENGINEER.
a. Prior to disinfection, clean piping as specified and flush thoroughly.
b. Conform to procedures described in ANSI/AWWA C651. Use continuous feed method of disinfecting, unless alternative method is acceptable to ENGINEER.
3. Water for initial flushing, testing, and disinfection will be furnished by OWNER. CONTRACTOR shall provide all temporary piping, hose, valves, appurtenances, and services required. Cost of water required for redisinfection will be paid by CONTRACTOR to OWNER at water utility's standard rates.
4. Chlorine shall be provided by CONTRACTOR.
5. Bacteriologic tests will be performed by OWNER. Certified test laboratory report will be provided to CONTRACTOR, if requested.
6. Chlorine concentration in water entering the piping shall be between 50 and 100 ppm, such that minimum residual concentration of 25 mg/L remains after 24-hour retention period. Disinfect piping and all related components. Repeat as necessary to provide complete disinfection.
7. After required retention period, flush chlorinated water to closed drain line, unless otherwise acceptable to ENGINEER. Properly dispose of chlorinated water in accordance with Laws and Regulations. Do not discharge chlorinated water to storm sewers, ditches, or overland.

3.7 BURIED PIPE HARNESS FORMULA

FORMULA FOR DETERMINATION
OF BURIED PIPE
HARNESSED LENGTHS
Lengths shall be based on the following:

$$\text{Harnessed Length (L) on each side of bend} = \frac{T}{f \sum W}$$

$T = 1.25\ PA \sin \Delta/2$

T = Thrust (lbs).

P = Test Pressure (psi).

A = Pipe Area (sq.in.).

Δ = Angle of Bend.

f = friction factor between soil and pipe = 0.3*.

$\sum W = Wp + Ws + Ww$.

Wp = weight pipe (pounds per linear foot-PLF).

Ws = weight soil (PLF)**.

Ww = weight fluid (PLF).

* For ductile iron pipe: Friction factor = 0.1.

** Unit weight of soil used to calculate harnessed lengths for buried pipe shall not be greater than 100 pounds per cubic foot.

3.8 SCHEDULES

A. Schedules listed below, following the "End of Section" designation, are part of this Specification section.
   1. Table 15051-A, Buried Piping Schedule.

+ + END OF SECTION + +

TABLE 15051-A, BURIED PIPING SCHEDULE

Service	Diameter (inch)	Material	Coating/ Lining	Thickness/ Pressure Class	Joint	Test
BD	6 to 8	DI	BC / CL	Pressure Class 350	RMJ	HYD (50 psig)
BW	8	DI	BC / CL	Pressure Class 350	RMJ	HYD (150 psig) DBT
CFC	4	PVC	-	Schedule 80	SW	NR
CFT	1 ID	Braided Vinyl	-	1" ID x 1-5/16" OD x 5/32" Wall	Hose barb and SS pipe clamp	HYD (75 psig)
D	4 to 16	DI	BC / CL	Pressure Class 350 12" & Smaller / Pressure Class 250 Larger Than 12"	RMJ	HYD (50 psig)
FI	42	DI	BC / CL	Pressure Class 250	RMJ	HYD (50 psig) DBT
FTWR	12	DI	BC / CL	Pressure Class 350	RMJ	HYD (150 psig)
FP	6	DI	BC / CL	Pressure Class 350	RMJ	HYD (150 psig) DBT
FM	4	DI	BC / CL	Pressure Class 350	RMJ	HYD (150 psig)
GC	4	PVC	-	Schedule 80	RJ	NR
GEQOF	16	DI	BC / CL	Pressure Class 250	RMJ	HYD (50 psig)
GPSOF	24	DI	BC / CL	Pressure Class 250	RMJ	HYD (50 psig)
GPSS	24 to 30	DI	BC / CL	Pressure Class 250	RMJ	HYD (50 psig) DBT
GS	24	DI	BC / CL	Pressure Class 350	RMJ	HYD (150 psig) DBT
GUTW	24	DI	BC / CL	Pressure Class 350	RMJ	HYD (150 psig) DBT
PTO	30	DI	BC / CL	Pressure Class 250	RMJ	HYD (50 psig) DBT
PW	3/4	PVC		Schedule 80	SW	HYD (150 psig) DBT
RD	6	DI	BC / CL	Pressure Class 350	RMJ	HYD (50 psig)
RW	24	DI	BC / CL	Pressure Class 250	RMJ	HYD (150 psig) DBT

Service	Diameter (inch)	Material	Coating/ Lining	Thickness/ Pressure Class	Joint	Test
RM	6	DI	BC / CL	Pressure Class 350	RMJ	HYD (150 psig)
S	6 to 15	PVC	-	SDR 35	BS	AIR
SBWS	12	DI	BC / CL	Pressure Class 350	RMJ	HYD (200 psig) DBT
SL	¾ to 1	PVC	-	Schedule 80	SW	HYD (50 psig) DBT
SS	≤ 12	PVC	-	SDR 35	BS	AIR
SS	>12	RCP	-	Class III, minimum	BS	AIR
TFI	24	PVC	-	C 905 CI OD DR 25	RJ	HYD (50 psig) DBT

The following abbreviations are used in the Buried Piping Schedule.

A. Buried Pipe Service Abbreviations

Service	Abbrev
Basin Drain	BD
Backwash	BW
Chemical Feed Carrier Pipe	CFC
Chemical Feed Tubing	CFT
Drain	D
Filter Influent	FI
Filter to Waste Return	FTWR
Fire Protection	FP
Sanitary Force Main	FM
Gas	GAS
Gas Carrier Pipe	GC
GAC EQ Basin Overflow	GEQOF
GAC Feed Pump Station Overflow	GPSOF
GAC Feed Pump Station Supply	GPSS
GAC Supply	GS
GAC/UV Treated Water	GUTW
Preliminary Treatment Overflow	PTO
Roof Drain	RD
Raw Water	RW
Residuals Main	RM
Sanitary Sewer	S
Sample Line	SL
Secondary GAC Backwash Supply	SBWS
Storm Sewer	SS
Temporary Filter Influent	TFI

B. Material Abbreviations

Material	Abbrev
Ductile Iron	DI
Stainless Steel	SS
Copper	C
Reinforced Concrete Pipe	RCP
Polyvinyl Chloride	PVC
Polyethylene	PE
High Density Polyethylene	HDPE

C. Lining/Coating Abbreviations

Lining	Abbrev
Bituminous Coated	BC
Cement Mortar Lined	CL
Fusion Bonded Epoxy Lined	FBEL

D. Joint Abbreviations

Joint Type	Abbrev
Bell and Spigot	BS
Push-on Joint	POJ
Mechanical Joint	MJ
Restrained Mech. Joint*	RMJ
Soldered	Sd
Brazed	Bz
Solvent Weld	SW

Note*: Restrained joints shall be provided to achieve minimum harnessed lengths as required by Paragraph 3.3.D.2.e for pipe not covered by Paragraph 3.3.D.1.

E. Test Abbreviations

Test	Abbrev
Hydrostatic Test (test pressure in psig)	HYD ( )
Low-pressure Air Sewer Test	AIR
Vertical Deflection	VD
Chlorine Pipe Test	CL
Disinfection and Bacteriological Testing	DBT
No Test Required	NR

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SECTION 15052

EXPOSED PIPING INSTALLATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified, and required to install and test all exposed piping, fittings, and specials. The Work includes the following:
      a. All types and sizes of exposed piping, except where exposed piping installations are specified under other Sections.
      b. Unless otherwise shown or specified, this Section includes all piping beginning at the outside face of structures or structure foundations and extending into the structure. Piping embedded in concrete within a structure or foundation shall be considered as exposed and is included herein. Piping that is permanently or intermittently submerged, or installed in sub-aqueous environments, is considered as exposed and is included in this Section.
      c. Work on or affecting existing exposed piping.
      d. Installation of all jointing and gasket materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, and all Work required for a complete exposed piping installation.
      e. Supports, restraints, and other anchors.
      f. Field quality control, including testing.
      g. Cleaning and disinfecting.
      h. Incorporation of valves, meters, and special items shown or specified into the piping systems per the Contract Documents and as required

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before exposed piping Work.
   2. Coordinate with appropriate piping Sections of Division 15, Mechanical.

C. Related Sections:
   1. Section 09910, Painting
   2. Division 15, applicable sections on Piping, Valves and Appurtenances.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ASME Boiler and Pressure Vessel Code.

2. ASME B31.3, Process Piping.
3. ASTM B32, Specification for Solder Metal.
4. AWS D1.1/D1.1M, Structural Welding Code-Steel.
5. ANSI/AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
6. ANSI/AWWA C600, Installation of Ductile Iron Water Mains and Their Appurtenances.
7. ANSI/AWWA C606, Grooved and Shouldered Joints.
8. ANSI/AWWA C651, Disinfecting Water Mains.
9. AWWA M9, Concrete Pressure Pipe.
10. AWWA M11, Steel Pipe - A Guide for Design and Installation.
11. AWWA M23, PVC Piping - Design and Installation.
12. AWWA M41, Ductile-Iron Pipe and Fittings.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:
1. Comply with requirements and recommendations of authorities having jurisdiction over the Work, including:
2. Comply with requirements of UL, FM and other jurisdictional authorities, where applicable.
3. Refer to the General and Supplementary Conditions regarding requirements for this Project.
4. Comply with the requirements of the Uniform Building Code as supplemented by the local authority, having jurisdiction.

1.4 SUBMITTALS

A. Action Submittals: Submit the following Shop Drawings:
1. Detailed drawings in plan and, as applicable, section.
2. Details of piping, valves, supports, accessories, specials, joints, harnessing, and main anchor supports, and connections to existing piping, structures, equipment, and appurtenances.
3. Submit description of proposed testing methods, procedures, and apparatus, and obtain ENGINEER’s approval prior to testing.

B. Test Reports:
1. Submit copies of testing report for each test.

C. Certificates:
1. Submit a certificate signed by manufacturer of each product certifying:
a. That product conforms to applicable referenced standards.
b. Welder’s Certificate to comply with Paragraph 3.1.E.7.c.

D. Record Documents:

1. Maintain accurate and up-to-date record documents showing field and Shop Drawing modifications. Record documents for exposed piping Work shall show actual location of all piping and appurtenances on a copy of the Drawings, unless otherwise approved by ENGINEER.
2. Record documents shall show piping with elevations referenced to the project datum and dimensions from permanent structures. For straight runs of pipe provide offset dimensions as required to document pipe location.
3. Include section drawings with exposed piping record documents when the Contract Documents include Section Drawings.
4. Conform to Section 01782, Record Documents.

1.5 DELIVERY, STORAGE AND HANDLING

A. Delivery:
   1. Deliver products to Site to ensure uninterrupted progress of the Work.
   2. Upon delivery, inspect pipe and appurtenances for cracked, gouged, chipped, dented, and other damage and immediately remove damaged products from Site.
   3. Conform to requirements of Section 01651, Transportation and Handling of Products.

B. Storage:
   1. Store products for convenient access for inspection and identification. Store products off the ground using pallets, platforms, or other supports. Protect packaged products from corrosion and deterioration.
   2. Pipe and fittings other than thermoplastic materials may be stored outdoors without cover. Thermoplastic pipe and fittings stored outdoors shall be covered.
   3. Conform to requirements of Section 01661, Storage and Protection of Products.

C. Handling:
   1. Handle pipe, fittings, specials, and accessories carefully with approved handling devices. Do not drop or roll material of delivery vehicles. Do not otherwise drop, roll, or skid piping.
   2. Avoid unnecessary handling of pipe.
   3. Keep pipe interiors free of dirt and foreign matter.
   4. Protect interior linings and exterior coatings of pipe and fittings from damage. Replace pipe and fittings with damaged lining regardless of cause of damage. Repair damaged coatings.
   5. Conform to requirements of Section 01651, Transportation and Handling of Products.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Piping materials are specified in the Exposed Piping Schedule at the end of this Section. Piping materials shall conform to Specification for each type of pipe and piping appurtenances in applicable sections of Division 15, Mechanical.

B. Markings and Identification:
   1. Pipe Markings:
      a. Clearly mark each piece of pipe or fitting with a designation conforming to that shown on the approved Shop Drawings.
      b. Manufacturer shall cast or paint on each length of pipe and each fitting the pipe material, diameter, and pressure or thickness class.
   2. Pipe Identification Markers and Arrows: Refer to Section 10400, Identification Devices.

C. Appurtenances: Provide products that conform to:
   1. Section 15055, Pipe Hangers and Supports.
   2. Section 15120, Piping Specialties and Accessories.
   3. Section 15121, Wall Pipes, Floor Pipes and Pipe Sleeves.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:
   1. Install piping as shown, specified and as recommended by the pipe and fittings manufacturer.
   2. If there is a conflict between manufacturer's recommendations and the Contract Documents, request in writing instructions from ENGINEER before proceeding.
   3. Provide pipe manufacturer’s installation specialist at Site as specified on this Section.
   4. CONTRACTOR shall confirm the pipe class and flange pattern of existing pipe and valves that are to be connected to or reinstalled prior to ordering proposed pipe.

B. Temporary Blind Flanges, Plugs, Caps, and Bulkheads:

1. Temporarily plug installed pipe at the end of each day of work or other interruption of pipe installation to prevent entry of animals, liquids, and persons into pipe, and entrance or insertion of deleterious materials into pipe.
2. Install standard plugs in all bells at dead ends, tees, and crosses. Cap all spigot and plain ends.
3. Fully secure and block blind flanges, plugs, caps, and bulkheads installed for testing, designed to withstand specified test pressure.
4. Where plugging is required for phasing of Work or subsequent connection of piping, install watertight, permanent type blind flanges, plugs, caps, or bulkhead acceptable to ENGINEER.

C. Piping Installation:
   1. Conform to manufacturer's instructions and requirements of standards and manuals listed in this Section, as applicable:
      a. Ductile Iron Pipe: ANSI/AWWA C600, AWWA M41.
      b. Steel Pipe: ASME B31.3, ANSI/AWWA C206, AWWA M11.
      c. Thermoplastic Pipe: AWWA M23
   2. Install straight runs true to line and elevation.
   3. Install vertical pipe truly plumb in all directions.
   4. Install piping parallel or perpendicular to walls of structures. Piping at angles and 45 degree runs across corners of structures will not be accepted unless specifically shown on the Contract Documents or approved by the ENGINEER.
   5. Install small diameter piping generally as shown when specific locations and elevations are not indicated. Locate such piping as required to avoid ducts, equipment, beams, and other obstructions.
   6. Install piping to leave all corridors, walkways, work areas, and similar spaces unobstructed. Unless otherwise approved by ENGINEER provide a minimum headroom clearance under piping and pipe supports of 7.5 feet. Clearances beneath piping shall be measured from the outermost edge of piping, flanges or other type of joint that extends beyond the nominal outside diameter of piping.
   7. Protect and keep clean interiors, fittings, and valves of pipe that will convey potable water, chemicals, and other pipe designated by ENGINEER.
   8. Cutting: Cut pipe from measurements verified at Site. Field cut pipe, where required, with a machine specially designed for cutting type of pipe being installed. Make cuts carefully without damage to pipe, coating, or lining, and with a smooth end at right angles to axis of pipe. Cut ends of push-on joint type pipe shall be tapered and sharp edges filed off smooth. Do not flame-cut pipe.
   9. Additional General Requirements for FRP and Thermoplastic Piping:
      a. Utilize wide band supports as recommended by pipe manufacturer and approved by ENGINEER to minimize localized stresses.
      b. Provide piping passing through walls with a sleeve of wearing material to prevent abrasion damage to piping.
      c. Provide anchored supports at elbows, valves, bends in piping, and at connections to equipment and tanks.

d. Spacing of supports shall be in accordance with the manufacturer's published recommendations at maximum design operating temperature of pipe.
e. Provide U-clamps with wide band circumferential contact.
f. Provide guides on long runs of piping to maintain alignment and reduce chance of elastic failure of pipe. Space guides as recommended by pipe manufacturer.
g. Provide anchored supports to restrain joints that allow expansion. Minimize use of bellows style joints. Where required and approved by the ENGINEER provide bellows style joints with low axial force to take up pipe expansion. Flexible connectors may be used to absorb thermal movement when approved in writing by ENGINEER.

D. Jointing Pipe:
1. General:
a. Make joints in accordance with pipe manufacturer's recommendations and Contract Documents.
b. Cut piping accurately and squarely and install without forcing or springing.
c. Ream out pipes and tubing to full inside diameter after cutting. Remove all sharp edges on end cuts.
d. Remove all cuttings and foreign matter from inside of pipe and tubing before installation. Thoroughly clean all pipe, fittings, valves, specials, and accessories before installing.
2. Ductile Iron Proprietary Joints:
a. Pipe that utilizes proprietary joints for restraint specified in Section 15061, Ductile Iron Pipe, or other such joints, shall be installed in accordance with manufacturer's instructions.
3. Ductile Iron and Steel Flanged Joints:
a. Assemble flanged joints using ring-type gaskets, with thickness as recommended by pipe manufacturer but not less than 1/8-inch thick, for raised-face flanges. Use full-face gaskets for flat-face flanges, unless otherwise approved by ENGINEER or recommended by pipe manufacturer. Gaskets shall be suitable for the service intended in accordance with the manufacturer's ratings and instructions. Gaskets shall be properly centered.
b. Tighten bolts in a sequence that provides equal distribution of bolt loads.
c. Length of bolts shall be uniform. Bolts shall not project beyond the nut more than 1/4-inch or fall short of the nut when fully taken up. Machine-cut ends of bolts to be neatly rounded. Do not use washers.
d. Prior to assembly of flanged joints, lubricate bolt threads and gasket faces.
e. Alternately tighten bolts 180 degrees apart to compress the gasket evenly.
f. After assembly, coat all bolts and nuts, except stainless steel bolts and nuts, with same coating specified in Section 09910, Painting, for material of pipe and fittings being joined.

4. Field Welded Steel Pipe Joints:

a. Joints in steel pipe shall be butt welded or lap welded, except that flexible couplings, mechanical couplings, or flanged connections shall be provided at connections to valves, meters, and similar equipment, and where shown or specified.
b. Welding procedures and welder qualifications shall conform to ASME Boiler and Pressure Vessel Code Section IX or to American Welding Society Structural Welding Code D1.1/D1.1M, Section 5, whichever is required. Welding of steel water pipe shall conform to the requirements of AWWA C206.
c. For all piping, submit current certificates that all welders and welding operators have been qualified in accordance with ASME Boiler and Pressure Vessel Code Section IX or American Welding Society Structural Welding Code D1.1/D1.1M, Section 5, whichever is required.
d. Conform to field welding procedures recommended by pipe manufacturer and as specified herein.
e. Clean ends to be welded up to at least 1/2-inch beyond the estimated toe of weld by sandblasting or other means to remove surface contamination such as paint, oil, grease, scale, oxide, rust, and other contamination.
f. Verify that ends to be welded are adequately prepared in shop for welding.
g. Provide full penetration welds, free of cracks, overlap and cold laps.
h. Preheat and interpass temperatures shall be not less than 60 degrees F and not more than 350 degrees F, respectively.
i. Limit on Undercut: 1/32-inch or ten percent of base metal thickness, whichever is less.
j. For pipe wall thickness up to 11-gauge (0.125-inch) use GTAW (Gas Tungsten Arc Welding).
k. For pipe wall thickness greater than 11-gauge, use GTAW root pass followed by GMAW (Gas Metal Arc Welding) or SMAW (Shielded Metal Arc Welding) Cap.
l. Where required for pipes 36-inch diameter and larger, and heavier-wall pipes, provide joints double beveled and welded from both inside and outside with the flux core process.
m. Provide internal inert gas purge to exclude atmosphere.
n. Filler Wire: ELC grade, of matching composition or of higher molybdenum content.
o. Weld Thickness: Equal to or greater than parent metal. Strength of welded joints shall be equal to or greater than strength of pipes being joined.
p. All welds shall be smooth with an internal crown of 1/16-inch or less, and external crown of 3/32-inch or less.
q. For grinding operations, use iron-free grinding wheels.
r. After welding, joint and the surrounding damaged or uncoated area shall be coated with same coating and thickness as shop applied coating.
s. Tack Welds: Make tack welds when required to aid in joining, with same grade of filler metal as for finished welds. For finish welding, either

completely remove tack welds or grind starting and finishing ends of tack welds for incorporation into finished welds.

t. Clean and de-scale all welds per ASTM A380.

5. Steel Pipe Threaded Joints:
   a. For threaded joints, use standard, right hand tapered full depth threads on steel piping and apply a manufacturer's recommended joint compound to male threads only, before installation.
   b. Remove cuttings and foreign matter from inside of pipe.
   c. Thoroughly clean all pipe, fittings, valves, specials, and accessories before installing.
6. Thermoplastic Pipe Joints:
   a. Solvent Cement Welded Joints:
      1) Bevel pipe ends and remove all burrs before making joint. Clean pipe and fittings thoroughly. Do not make solvent cement joints if temperature is below 40 degrees F. Do not make solvent cement welded joints in wet conditions.
      2) Use solvent cement supplied or recommended by pipe manufacturer.
      3) Apply joint primer and solvent cement and assemble joints in accordance with recommendations and instructions of manufacturer of joint materials and pipe manufacturer.
      4) Implement appropriate safety precautions when using joint primers and solvent cements. Allow air to circulate freely through pipelines to allow solvent vapors to escape. Slowly admit fluid when flushing or filling pipelines to prevent compression of gases within pipes.
   b. Threaded Joints:
      1) Cut pipe square and smooth and remove burrs or raised edges with a knife or file.
      2) Hold pipe firmly in a pipe vise. Protect pipe at the point of grip by inserting a rubber sheet or other material between pipe and vise.
      3) Thread pipe in accordance with pipe manufacturer's recommendations. Brush threads clean of chips and ribbons.
      4) After threading pipe**,** starting with second full thread, and continuing over thread length, wrap 100-percent virgin TFE (Teflon) thread tape in direction of threads. Overlap each wrap by one-half width of tape.
      5) After application of the TFE thread tape, screw fitting or coupling onto the pipe end to be joined and tighten by hand. Using a strap wrench only, further tighten connection an additional one to two threads past hand tightness.
7. Copper Tubing Joints:
   a. Soldered Joints:
      1) Assemble copper tubing with soldered joints. Solder shall be 95-5 tin-antimony solder conforming to ASTM B32.
      2) Ream or file pipe to remove burrs.
      3) Clean and polish contact surfaces of joints.
      4) Apply flux to both male and female ends.
      5) Insert end of tube into full depth of fitting socket.

6) Heat joint evenly.
7) Form continuous solder bead around entire circumference of joint starting at the bottom.

8. Mechanical Coupling Joints:
   a. Mechanical couplings include: sleeve-type flexible couplings, split flexible couplings, ANSI/AWWA C606 grooved or shouldered end couplings, plasticized PVC couplings, and other mechanical couplings used.
   b. Prior to installing and assembling mechanical couplings, thoroughly clean joint ends with a wire brush to remove foreign matter.
   c. For mechanical couplings that incorporate gaskets, after cleaning apply lubricant to rubber gasket or inside of coupling housing and to joint ends. After lubrication, install gasket around joint end of previously installed piece and mate joint end of subsequent piece to installed piece. Position gasket and place coupling housing around gasket and over grooved or shouldered joint ends. Insert bolts and install nuts tightly by hand. Tighten bolts uniformly to produce an equal pressure on all parts of housing. When housing clamps meet metal to metal, joint is complete and further tightening is not required.
   d. For plasticized PVC couplings, loosen the stainless steel clamping bands and remove the clamps from the coupling. Slide the coupling over the plain ends of the pipes to be joined without using lubricants. Place clamps over each end of coupling at grooved section and tighten with a torque wrench to torque recommended by manufacturer.

E. Installing Valves and Accessories:
   1. Provide supports for large valves, flow meters, and other heavy items as shown or required to prevent strain on adjoining piping.
   2. Position flow measuring devices in pipe lines so that they have the amount of straight upstream and downstream runs recommended by the flow measuring device manufacturer, unless specific location dimensions are shown.
   3. Position swing check valves and butterfly valves so that they do not conflict with upstream and downstream elements of the piping system.
   4. Install floor stands as shown and as recommended by the manufacturer.
   5. Provide lateral restraints for extension bonnets and extension stems as shown and as recommended by the manufacturer.
   6. Provide steel sleeves where operating stems pass through floor. Extend sleeves 2-inches above floor.
   7. Position valve operators as shown. When the position is not shown, install the valve so that it can be conveniently operated and as approved by ENGINEER. Avoid placing operators at angles to the floors or walls.

F. Unions:
   1. Install dielectric unions as specified in Section 15120, Piping Specialties and Accessories**,** where dissimilar metals are connected, except for bronze or brass valves in ferrous piping.
   2. Provide a union downstream of each valve with screwed connections.

3. Provide screwed or flanged unions at each piece of equipment, where shown, and where necessary to install or dismantle piping.

G. Transitions from One Type of Pipe to Another:
   1. Provide all necessary adapters, specials, and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.

H. Closures:
   1. Provide closure pieces, such as blind flanges and caps, shown or required to complete the Work.

I. Eccentric Reducers:
   1. Use eccentric reducers where shown and where air or water pockets would otherwise occur in mains because of a reduction in pipe size.

3.2 THRUST RESTRAINT

A. Provide thrust restraint on all pressure piping systems and where otherwise shown or specified.

B. Thrust restraints shall be designed for axial thrust exerted by test pressure specified in the Exposed Piping Schedule at end of this Section.

C. Restrained Pipe Joints:
   1. Pipe joints shall be restrained by means suitable for the type of pipe being installed.
      a. Ductile Iron, Push-on Joints and Mechanical Joints: Restrain with a proprietary restrained joint system as specified in Section 15061, Ductile Iron Pipe, Lugs, and Tie Rods, or ther joint restraint systems approved by ENGINEER. Restrain ductile iron pipe connected by flexible couplings or flanged coupling adapters by harnessing across the coupling or adapter using tie rods or extended bolts connecting between flanges.
      b. Steel Pipe Joints: Provide butt-welded joints, lap welded joints, flanged joints, or mechanical coupling connections as shown and specified in Exposed Piping Schedule. Provide tie rods connected to lugs welded to the steel pipe for restraint at mechanical couplings.
      c. Thermoplastic, FRP and HDPE Joints: Where bell and spigot-type or other non-restrained joints are utilized, provide tie rods across the joint or other suitable joint restraint system, subject to approval of ENGINEER.

3.3 WORK AFFECTING EXISTING PIPING

A. Location of Existing Piping:
   1. Locations of existing piping shown on Drawings is approximate.

2. Determine the true location of existing piping to which connections are to be made, crossed, and that could be disturbed, and determine location of other facilities that could be affected by the Work.

B. Taking Existing Pipelines Out of Service:
   1. Conform to Section 01143, Coordination with Owner's Operations.

C. Work on Existing Pipelines:
   1. Cut or tap pipes as shown or required with machines and tools specifically designed for cutting or tapping pipelines.
   2. Install temporary plugs to prevent entry of mud, dirt, water, and debris into pipe.
   3. Provide necessary adapters, sleeves, fittings, pipe, and appurtenances required to complete the Work.
   4. Conform to applicable requirements of Section 01143, Coordination with Owner's Operations and Section 01724, Connections to Existing Facilities.

3.4 PAINTING

A. Field painting shall conform to Section 09910, Painting.

3.5 FIELD QUALITY CONTROL

A. Testing, General:
   1. Test all piping, except as exempted in the Exposed Piping Schedule.
   2. Notification:
      a. Notify ENGINEER at least 48 hours prior to testing.
      b. When authorities having jurisdiction are to witness tests, notify ENGINEER and authorities having jurisdiction in writing at least 48 hours in advance of testing.
   3. Conduct all tests in presence of ENGINEER.
   4. Remove or protect pipeline-mounted devices that could be damaged by testing.
   5. Provide all apparatus and services required for testing, including:
      a. Test pumps, compressors, hoses, calibrated gages, meters, test containers, valves, fittings, and temporary pumping systems required to maintain OWNER's operations.
      b. Temporary bulkheads, bracing, blocking, and thrust restraints.
   6. Provide air if an air test is required, power if pumping is required, and gases if gases are required.
   7. Unless otherwise specified, OWNER will provide fluid required for hydrostatic testing. CONTRACTOR shall provide means to convey fluid for hydrostatic testing into the pipe being tested. CONTRACTOR shall provide fluid for other types of testing required.
   8. Repair observed leaks and repair pipe that fails to meet acceptance criteria. Retest after repair.

9. Unless otherwise specified, testing shall include existing piping systems that connect with new piping system. Test existing pipe to nearest valve. Piping not installed by CONTRACTOR and that fails the test shall be repaired upon authorization of ENGINEER or OWNER. Repair of existing piping will be paid as extra work unless otherwise specified.
10. When testing existing chlorine gas and sulfur dioxide gas systems to the nearest isolation valve, provide a tee in the line adjacent to valve. Branch outlet on tee shall be provided with a valve and used for cleaning, testing, draining, and drying pipe. Unless otherwise indicated, existing chlorine or sulfur dioxide system shall not be shut down during testing or for installing tee and valve. Prior to placing the pipeline in service, valve on the branch outlet of tee shall be plugged or sealed with a blind flange or threaded plug. Repair damage to system as a result of this Work at no extra cost to OWNER.

B. Test Schedule:
   1. Refer to the Exposed Piping Schedule for type of test required and required test pressure.
   2. Unless otherwise specified, the required test pressures are at lowest elevation of pipeline segment being tested.
   3. For piping not listed in Exposed Piping Schedule:
      a. Hydrostatically test pipe that will convey liquid at a pressure greater than five psig. Provide process air pipe test for pipe that will convey air or gas under pressure or vacuum, except chlorine gas, which requires a separate test.
      b. Disinfect for bacteriological testing piping that conveys potable water.
   4. Test Pressure:
      a. Use test pressures listed in Exposed Piping Schedule.
      b. If test pressure is not listed in Exposed Piping Schedule, or if a test is required for piping not listed in the Exposed Piping Schedule, test pressure will be determined by the ENGINEER based on the maximum anticipated sustained operating pressure and the methods described in the applicable ANSI/AWWA manual or standard that applies to the piping system.

C. Hydrostatic Testing:
   1. Preparation for Testing:
      a. For thermoplastic pipe and FRP pipe, follow procedures described in Section 7 of ANSI/AWWA Standard C605.
      b. For steel pipe, follow procedures described in AWWA Manual M11. Wetting period is not required for pipe that is not cement-lined.
      c. For other piping follow procedures described in AWWA Manual M9. A wetting period is not required for pipe that is not cement mortar-lined.
      d. Prior to testing, ensure that adequate thrust protection is in place and all joints are properly installed.
   2. Test Procedure:

a. Fill pipeline slowly to minimize air entrapment and surge pressures. Fill rate shall not exceed one foot of pipe length per second in the pipe being tested.
b. Expel air from pipe as required. Obtain approval of ENGINEER prior to tapping pipe for expelling air.
c. Examine joints and valves, and make repairs to eliminate visible leakage.
d. After specified wetting period, add fluid as required to pressurize line to required test pressure. Maintain test pressure for a stabilization period of ten minutes before beginning test.
e. Timed test period shall not begin until after the pipe has been filled, exposed to the required wetting period, air has been expelled, and pressure stabilized.
f. Timed Test Period: After the stabilization period, maintain test pressure for at least two hours. During timed testing period, add fluid as required to maintain pressure within five psig of required test pressure. The test pressure shall then remain steady for one hour, indicating no leakage.
g. Pump from a test container to maintain test pressure. Measure volume of fluid pumped from test container and record on test report. Record pressure at test pump at fifteen minute intervals for duration of test.

3. Allowable Leakage Rates: Leakage is defined as the quantity of fluid supplied to pipe segment being tested to maintain pressure within five psi of the test pressure during timed test period. Allowable leakage rates for piping are:
   a. No Leakage: Pipe with flanged, welded, fused, threaded, soldered, or brazed joints.

D. Process Air Pipe Testing:
1. General:
   a. Required test pressure is listed in Exposed Piping Schedule.
2. Preparation for Testing:
   a. Provide temporary tie rods at expansion joints as required.
   b. Verify that pipe supports, where present, are secure.
   c. Test one pipe segment at a time. Use temporary blind flanges and isolators as required.
   d. Install corporation cocks for filling and relieving air. Provide temporary automatic pressure relief valve and pressure gauge with range suitable for test pressure.
3. Test Procedure:
   a. Pressurize pipe segment being tested with air to the required test pressure. Maintain pressure for at least two hours.
   b. Apply a soapy water solution to all joints to check for leakage, indicated by presence of bubbles, while test pressure is maintained.
   c. Allowable Leakage: Zero
4. Repair and retest pipelines that fail the test.
5. After testing is complete remove temporary measures provided for testing and provide Type 304 stainless steel threaded plugs at taps used for testing.

E. Chlorine Piping:
   1. Scope: Applicable to chlorine gas piping and liquid chlorine piping systems that are either under vacuum or positively pressurized.
   2. General:
      a. Testing includes pressure testing, drying, and air or nitrogen leak testing as specified, and service gas leak testing. Pressure-test system after cleaning.
      b. Relative to chlorine testing, the term "plastic piping" includes the following types of pipe: PVC, CPVC, ABS, FRP, polypropylene (PP), PTFE, PFA, PVDF, ethylene chlorotrifluoroethylene (ECTFE), and ethylene tetrafluoroethylene (ETFE).
      c. Do not attempt to repair leaks until pressure has dissipated from system.
      d. Repair and retest system until successful test is performed.
      e. When piping is filled with chlorine, implement appropriate precautions relative to safety and minimizing the potential for leaks.
   3. Evaporator-supplied Systems:
      a. Disconnect vent from discharge side of pressure relief valve of each evaporator, plug resultant opening, inspect, and secure all joints, close valves that discharge to atmosphere, and open all inline valves. Open valve in bypass line around pressure reducing valve on downstream side of each evaporator to provide a through path around valve.
      b. Test system as specified.
      c. After testing, restore equipment, valves, and piping to pre-test positions and close inline valves. Reconnect vent line to downstream side of pressure relief valve of each evaporator and close valve in bypass line around the pressure reducing valve on downstream side of each evaporator.
   4. Pressure Testing:
      a. Fill pipe with water and hydrostatically test in accordance with Paragraph 3.5.D. of this Section.
      b. Hydrostatic test pressure shall be per the Exposed Piping Schedule. When hydrostatic test pressure is not specified in Exposed Piping Schedule, for pressure piping ENGINEER will direct CONTRACTOR to use test pressure of 1.5 times the maximum operating pressure to which the system may be subjected. If not otherwise specified in the Exposed Piping Schedule, hydrostatically test vacuum piping to at least 25 psig.
      c. After hydrostatic testing, replace all moisture absorbing gaskets and valve packing.
      d. Steel Pipe: If drying after hydrostatic testing is impractical or cannot be accomplished, test steel piping by either pneumatic testing or alternate testing (weld examination) per Chlorine Institute Pamphlet No. 6. When performing pneumatic test, implement safety precautions to safeguard personnel and minimize risk.
   5. Drying:

a. Chlorine piping systems shall be dried prior to placing in service. Drying is required for all piping regardless of whether water has been purposely introduced to the system.
b. Steel Pipe: Drying shall be accomplished by passing steam through piping from high end of system until piping is heated to approximately 200 degrees F unless lower temperature is required to protect the system from damage. While steaming, allow condensate and foreign matter to drain from the pipe. Disconnect steam supply and drain pockets and low spots in the pipe. While the pipe is still warm, blow dry, oil-free air with a dew point of -40 degrees F or below, or nitrogen, through pipe until the exiting air dew point is equal to supply air dew point. Valves shall be at half-open position during drying. Valves removed temporarily from system during drying must be free of moisture before being re-installed.
c. Plastic Pipe: Dry gas piping only. Drain and remove all water and moisture from system. After draining, "pig" the pipe to remove excess water. Dry the system with air or nitrogen in accordance with requirements for steel pipe, except that steam shall not be used on plastic pipe.

6. Nitrogen or Air Leak Testing:
   a. Do not leak-test plastic piping with nitrogen or air.
   b. Use nitrogen gas or oil-free dry air to test steel piping. Gradually introduce nitrogen or dry air and pressurize to 50 psig. Maintaining this pressure while testing all joints along the pipe for leaks with soapy water solution. When system is free from leaks at this pressure, increase test pressure increments of approximately 50 psig up to the lower of either 150 psig or 110 percent of the maximum system operating pressure. After each increase in pressure, check for leaks using soapy water solution and implement corrective action as necessary.
   c. When the system has no leaks at final test pressure, system shall be depressurized, the test source disconnected, and the system capped to prevent the entrance of water.
   d. Nitrogen Gas: Use cylinders of dry, high-purity nitrogen gas, nitrogen handling cylinder mounted pressure regulator with 0 to 300 psig range, and necessary fittings and adapters to connect the source to the pipe being tested. Pressure regulator shall be self-relieving type, venting to atmosphere, and include a throttling valve.
   e. Dry Air: Provide oil-free air with a relative humidity of zero. Fittings, adapters, and accessories, pressure regulator, and throttling valve shall be suitable for pressure testing with air and rated for 300 psig.
7. Service Gas (Chlorine Gas) Leak Testing:
   a. After pressure testing and immediately after chlorine system has been dried, gradually introduce service gas to the pipe; service gas is the gas that will be conveyed through the pipe when it is in use. After gas has completely filled the pipe, increase the service gas pressure to 5 psig and check all joints for leaks.

b. Implement safety precautions to safeguard personnel and minimize risk when performing service gas leak test.
c. Use a liquid ammonia solution or chlorine gas detector to check for chlorine leaks. When using liquid ammonia solution, spray solution at pipe joints and connections. Do not squirt liquid on pipe or fittings. Chorine gas and ammonia solution will react to produce a dense, white cloud. Leaks in piping and equipment, if detected, shall not be repaired until all gas has been purged from the system being tested. Upon completion of repairs, repeat cleaning, drying, nitrogen or air leak testing, and service gas leak testing.
d. Do not perform service gas leak testing on liquid chlorine piping.

F. Examination of Welds:
1. Personnel performing examination of welds shall be qualified to at least Level II, in accordance with ASNT SNT-TC-1A.
2. Conform to ASME Boiler and Pressure Vessel Code Section V and applicable articles for examination of welds.
3. Visually examine all welds, Category D Fluid Service, in conformance with ASME B31.3.
4. Examine at least ten percent of welds using liquid penetrant examination.
5. If a defect is detected, all welds shall be examined by liquid penetrant examination.
6. At conclusion of liquid penetrant examination, remove penetrant test materials by flushing, washing, or wiping clean with applicable solvents.

G. Bacteriological Testing:
1. Bacteriological testing for potable water lines, finished water lines, and other piping per Exposed Piping Schedule, is specified in Article 3.6 of this Section.

3.6 CLEANING AND DISINFECTION

A. Cleaning, General: Clean pipe systems as follows:
1. Thoroughly clean all piping, including flushing with water, dry air, or inert gas as required, in a manner approved by ENGINEER, prior to placing in service. Flush chlorine solution and sodium hypochlorite piping with water.
2. Piping 24-inch diameter and larger shall be inspected from inside and debris, dirt and foreign matter removed.
3. For piping that requires disinfection and has not been kept clean during storage or installation, swab each section individually before installation with a five percent hypochlorite solution.

B. Cleaning of Gas and Air Piping:
1. Unless otherwise specified, non-chlorine gas and air system piping 6-inch diameter and smaller shall be blown out, using air or the testing medium specified. Piping larger than 6-inch diameter shall be cleaned by having a swab or “pig” drawn through each pipe reach.

2. After connecting to equipment, blow out pipe using the equipment.
3. Upon completion of cleaning, piping shall be drained and dried with blown air. Propane systems shall be purged with nitrogen and a nitrogen pad maintained at ten psi until put in service. Digester gas systems shall be purged with nitrogen and a nitrogen pad maintained at three psi until put in service.

C. Cleaning of Chlorine Gas and Liquid Chlorine Systems:
   1. General: All portions of system shall be cleaned free of oil and grease.
   2. Clean chlorine piping per procedures in Chlorine Institute Pamphlet No. 6.
   3. Steel Pipe:
      a. All pipe threads shall be washed clean and free from cutting oil.
      b. Remove from inside of pipe and fittings all pipe dope, oil, and grease by drawing a cloth wetted with solvent through each pipe segment, or other method acceptable to ENGINEER.
      c. Valves shall be dismantled, thoroughly cleaned with solvents, and repacked, if necessary, prior to installation.
      d. Cap or plug openings in pipe at end of each workday.
      e. When using solvents such as carbon tetrachloride or trichloroethylene, exercise caution times to minimize solvent exposure, and provide proper handling and disposal. Do not use solvents containing hydrocarbons or alcohols.
   4. Plastic Pipe: Clean vacuum and liquid piping with a detergent and water and thoroughly rinse to remove all detergent, after which a cleaning ball or swab shall be drawn through the pipe.

D. Disinfection:
   1. Disinfect all potable and finished water piping.
   2. A suggested procedure for accomplishing complete and satisfactory disinfection is specified below. Other procedures may be considered for acceptance by ENGINEER.
      a. Prior to disinfection, clean piping as specified and flush thoroughly.
      b. Conform to procedures described in ANSI/AWWA C651. Continuous feed method of disinfecting shall be used, unless alternative method is acceptable to ENGINEER.
   3. Water for initial flushing, testing, and disinfection will be furnished by OWNER. CONTRACTOR shall provide all temporary piping, hose, valves, appurtenances, and services required. Cost of water required for re-disinfection will be paid by CONTRACTOR to OWNER at the water utility's standard rates.
   4. Chlorine shall be provided by CONTRACTOR.
   5. Bacteriologic tests will be performed by OWNER. A certified test laboratory report will be provided to CONTRACTOR, if requested.
   6. Chlorine concentration in the water entering the piping shall be between 50 and 100 ppm, such that a minimum residual concentration of 25 mg/l remains after a 24-hour retention period. Disinfect the piping and all related components. Repeat as necessary to provide complete disinfection.

7. After required retention period, the chlorinated water shall be flushed to a closed drain line, unless otherwise directed by ENGINEER. Properly dispose of chlorinated water in accordance with applicable regulations. Do not discharge chlorinated water to storm sewers, ditches, or overland.

3.7 EXPOSED PIPING SCHEDULE

A. The schedules listed below, following the "End of Section" designation, are a part of this Specification section.
   1. Table 15052-A, Exposed Piping Schedule.

+ + END OF SECTION + +

TABLE 15052-A, EXPOSED PIPING SCHEDULE

Service	Size	Material	Lining	Thickness/ Pressure Class	Joint*	Test
BD	6 to 8	DI	CL	Class 53	Flg	HYD (50 psig)
CFC	4	PVC	-	Schedule 80	SW	NR
CFT	1 ID	Braided Vinyl	-	1" ID x 1-5/16" OD x 5/32" Wall	Hose barb and SS pipe clamp	HYD (75 psig)
D	4	DI	CL	Class 53	Flg	HYD (50 psig)
FI	42	DI	CL	Class 53	Flg	HYD (50 psig) DBT
BWS	10 & 8	DI	CL	Class 53	Flg	HYD (150 psig) DBT
BWW/VTW	10 & 8	DI	CL	Class 53	Flg	HYD (150 psig) DBT
GBP	24	DI	CL	Class 53	Flg	HYD (150 psig) DBT
GEQOF	16	DI	CL	Class 53	Flg	HYD (50 psig)
GEQR	4	DI	CL	Class 53	Flg	HYD (100 psig) DBT
GPSOF	24	DI	CL	Class 53	Flg	HYD (50psig)
GPSS	24	DI	CL	Class 53	Flg	HYD (50 psig) DBT
GS	24, 10 & 8	DI	CL	Class 53	Flg	HYD (150 psig) DBT
GTW	24, 10 & 8	DI	CL	Class 53	Flg	HYD (150 psig) DBT
GUTW	24	DI	CL	Class 53	Flg	HYD (150 psig) DBT
GUTW (Chem. Feed)	24	DI	P401	Class 53	Flg	HYD (150 psig) DBT
PA	1 to 2	C	---	Type K	Bz	AIR
PW(<4")	---	C	---	Type L	Sd	HYD (150 psig) DBT

Service	Size	Material	Lining	Thickness/ Pressure Class	Joint*	Test
PW(4" and Larger)	---	DI	CL	Class 53	Flg	HYD (150 psig) DBT
RD	6	DI	CL	Class 53	Flg	HYD (150 psig)
RM	6	DI	CL	Class 53	Flg	HYD (150 psig)
RW	24	DI	CL	Class 53	Flg	HYD (150 psig) DBT
SL	3/4 to 1	PVC	-	Schedule 80	SW	HYD (50 psig) DBT
SBWS	10 to 12	DI	CL	Class 53	Flg	HYD (200 psig) DBT
SR	6	DI	CL	Class 53	Flg	HYD (50 psig)
V	16	DI	CL	Class 53	Flg	NR

*Unless specifically shown or noted otherwise on the Drawings, the joint type shown in the Exposed Piping Schedule shall be used.

The following abbreviations are used in the Exposed Piping Schedule.

A. Exposed Pipe Service Abbreviations

Service	Abbrev.
Basin Drain	BD
Chemical Feed Carrier Pipe	CFC
Chemical Feed Tubing	CFT
Drain	D
Filter Influent	FI
GAC Backwash Supply	BWS
GAC Backwash Waste/Vessel-to-Waste	BWW/VTW
GAC Bypass	GBP
GAC EQ Basin Overflow	GEQOF
GAC EQ Basin Recycle	GEQR
GAC Feed Pump Station Overflow	GPSOF
GAC Feed Pump Station Supply	GPSS
GAC Supply	GS
GAC Treated Water	GTW
GAC/UV Treated Water	GUTW
Plant Air	PA
Plant Water	PW(<4”)
Plant Water	PW(>4”)
Potable Water	W
Recycle	R
Residuals Drain	RD
Residuals Main	RM
Sample Line	SL
Sanitary Sewer	S
Secondary GAC Backwash Supply	SBWS
Settled Residuals	SR
Sludge Drain	SD
Sump Pump Discharge	SPD
Vent	V

B. Material Abbreviations

Material	Abbrev
Ductile Iron	DI
Carbon Steel	CS
Stainless Steel	SS
Copper	C
Polyvinyl Chloride	PVC

C. Lining/Coating Abbreviations

Lining	Abbrev
Bituminous Coated	BC
Cement Mortar Lined	CL
Fusion Bonded Epoxy Lined	FBEL
Painted	P
Insulated	I
Galvanized	Galv
Protecto 401™	P401

D. Joint Abbreviations

Joint Type	Abbrev
Soldered	Sd
Flanged	Flg
Solvent Weld	SW
Braved	Bz

E. Test Abbreviations

Test	Abbrev
Hydrostatic Test (test pressure in psig)	HYD ( )
Air	AIR
Chlorine Pipe Test	CL
Disinfection and Bacteriological Testing	DBT
Examination of Welds	EW
No Test Required	NR

SECTION 15055

PIPE HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified and required to design, furnish, and install all hangers, supports and appurtenances necessary to complete the Work.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the pipe hangers and supports Work.

C. Related Sections:
   1. Section 03300, Cast-In-Place Concrete.
   2. Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts
   3. Section 05500, Metal Fabrications.
   4. Section 09910, Painting.
   5. Division 15, Sections on Piping, Valves and Appurtenances.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Society for Testing and Materials, (ASTM).
      a. ASTM A 575, Specification for Steel Bars Carbon, Merchant Quality, M-Grades.
      b. ASTM E 84, Test Method for Surface Burning Characteristics of Building Materials.
   2. Federal Specification, (FS).
      a. FS A-A-1192, Hangers, Pipe.
   3. Manufacturers Standardization Society of the Valve and Fittings Industry, (MSS).
      a. MSS SP 58, Pipe Hangers and Supports-Materials, Design and Manufacture.
      b. MSS SP 69, Pipe Hangers and Supports - Selection and Application.
   4. Underwriters' Laboratories, Inc., (UL).
      a. UL 203, Pipe Hanger Equipment for Fire Protection Service.

1.3 QUALITY ASSURANCE

A. Each type of pipe hanger or support shall be the product of one manufacturer.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single pipe hangers and supports manufacturer.
   2. The pipe hangers and supports equipment manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall assembly by the pipe hangers and supports equipment manufacturer.

1.4 SUBMITTALS

A. Shop Drawings: Submit the following:
   1. Detailed drawings showing all hangers and supports for each piping system specified. Shop Drawings shall show location, installation, material, loads or forces, and deflection of all hangers and supports. Each pipe system shall be analyzed for all loads and forces on the hangers and supports, and their reaction forces to the structure to which they are fastened.
   2. Submit and coordinate these with Shop Drawings required for all piping systems.

B. Product Information: Submit manufacturers' catalogs, literature, and engineering data on all hangers and supports. Load ratings, materials and installation shall be consistent with the recommendations of the MSS SP 58, MSS SP 69 and Federal Specification A-A-1192.

1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
   1. Deliver materials to the Site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of that Work.

B. Storage and Protection:
   1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
   2. Store materials in covered storage off the ground and prevent condensation.

C. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the Site. CONTRACTOR shall notify ENGINEER, in writing, if any loss or damage exists to equipment or components. Replace loss and

repair damage to new condition in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.1 GENERAL

A. Hangers and supports shall meet with the following requirements:
   1. Standard and fabricated hangers and supports shall be furnished complete with necessary inserts, bolts, nuts, rods, washers, and other accessories.
   2. Generally, run piping in groups where practicable and parallel to building wall. Provide minimum clearance of 1-inch between pipe and other work.
   3. Install hangers or supports at all locations where pipe changes direction.
   4. All hangers and supports shall be capable of adjustment after placement of piping.
   5. Different types of hangers or supports shall be kept to a minimum.
   6. All suspended or supported ductile iron pipe shall have a hanger or support adjacent to each hub.
   7. Support vertical piping at each floor and between floors by stays or braces to prevent rattling and vibration.
   8. Hanger rods shall be straight and vertical. Chain, wire, strap or perforated bar hangers shall not be used. Hangers shall not be suspended from piping.
   9. Maximum support spacing unless otherwise shown or approved for standard weight steel pipe shall be as follows:

Pipe Size (inches)	Maximum Pipe Span [1] (feet)			
	Steel	Copper	Plastic [2]	Cast/Ductile Iron [4]
3/8 to 3/4	5	6	Cont. [3]	-
1	6	6	5	-
1-1/4	6	6	5	-
1-1/2	6	6	5	-
2	10	10	5	-
2-1/2	10	10	5	-
3	10	10	5	-
4	12	12	5	12 feet for pressure pipe
6	12	12	5	
8	12	12	5	
10	12	-	5	
12	12	-	10	
14	12	-	-	
16	12	-	-	10 feet for soil pipe
18	12	-	-	

Pipe Size (inches)	Maximum Pipe Span [1] (feet)			
	Steel	Copper	Plastic [2]	Cast/Ductile Iron [4]
20	12	-	-	
24	12	-	-	

[1]Pipe shall not have pockets formed in the span due to sagging of the pipe between supports caused by the weight of the pipe, medium in the pipe, insulation, valves and fittings.

[2]Span shown is for Schedule 80 CPVC pipe at 100°F. Spans for other plastics, other CPVC pipe Schedules and pipes at higher temperatures shall be shortened in accordance with the pipe manufacturer's recommendations.

[3]Continuous means pipe shall be in unistrut or similar channel.

[4] Pipe hanger and support selection shall be as shown and in this Section.

10. Maximum support spacing, unless otherwise shown for plastic pipe at ambient temperature, shall be one-half of the values specified for steel pipe.
11. Plastic pipe at temperature greater than 130ºF shall be continuously supported in a metal cradle or tray.
12. Where proper hanger or support spacing does not correspond with joist or rib spacing, structural steel channels may be attached to joists or ribs and pipes suspended there from.
13. Prevent contact between dissimilar metals when supporting copper tubing, by use of copper plated, rubber or vinyl coated, or stainless steel hangers or supports.
14. Isolate thin walled stainless steel piping from carbon steel by use of plastic coated hangers or supports or by taping at points of contact with PVC or vinyl.
15. Supports and hangers shall be of a material that is compatible with the fluid being conveyed in such pipe being supported.
16. Anchors for pipe support systems shall be compatible or protected by a coating system which is compatible with the fluid being conveyed in such pipe being supported.

B. Expansion compensation shall be designed for individual exposed piping systems with the following Design Criteria:
   1. $\Delta L = L \times \Delta T \times \alpha$
      a. Where ΔL = pipe length change (inches).
      b. L = pipe length between anchors (inches).
      c. ΔT = 100 (F).
      d. α = coefficient of thermal expansion (inches/inches/F).
   2. Expansion compensation shall be designed as an integral part of the piping hanger, support and anchorage system.
   3. Expansion compensation shall be achieved via expansion joints specified in Section 15120, Piping Specialties and Accessories.

2.2 HANGERS AND SUPPORTS

A. Hangers and supports where shown shall be in accordance with detail drawings. Hangers and supports not shown shall be in accordance with MSS SP 58.

B. Products and Manufacturers: Provide one of the following:

Type	**Description**	**Manufacturers**
Adjustable wrought clevis	Hangers, ½ inch through 30 inch Pipe	Figure 260 by Grinnell Figure B3100 or B3102 by B-Line
Carbon Steel Pipe Clamp	Riser Clamps, ½ inch through 30 inch Pipe	Figure 261 by Grinnel Figure B3373 by B-Line
Cast iron saddle	Pipe Saddles, 1-1/2 inch through 36 inch Pipe	Figure 258 by Grinnell Figure B3095 by B-Line
Cast iron saddle with steel yoke and nuts	Pipe Stanchion Saddle, 2-1/2 inch through 36 inch Pipe	Figure 259 by Grinnell Figure B3090 by B-Line
Cast iron saddle and reducer with nipple	Adjustable Pipe Saddle Support, 2-1/2 inch through 36 inch Pipe	Figure 264 by Grinnell Figure B3093 by B-Line
Fabricated heavy duty steel bracket	Wall Brackets, ½ inch through 36 inch Pipe	Figure 199 by Grinnell Figure B3067 by B-Line
Channel Type Pipe Support	Hot dip galvanized steel conforming to ASTM A 570, Grade 33, 1-5/8 inches by 1-5/8 inches by 12 guage	Figure PS200 by Grinnell
O.D. Tubing Clamp	Strut mounted clamp	Figure PS1200 by Grinnell Figure B2000 by B-Line
Horizontal Pipe support at flange	Flange support. Connecting flange must meet ANSI B16.1 Class 125 and ANSI B16.5 Class 155 standards	Figure B3094 with B3088 base Stand by B-Line

Copper Pipe: ½ inch through 4-inch.

Type	**Description**	**Manufacturers**
Adjustable wrought clevis	Hangers for insulated Pipe	Figure 260 by Grinnell Figure B3100 by B-Line
Adjustable copper coated steel clevis	Hangers for uninsulated Pipe	Figure CT65 by Grinnell Figure B3104CT
Copper tubing riser clamp	Riser Clamps	Figure CT-121 by Grinnell Figure B3373CT by B-Line
Strut clamps for insulated copper tubing	Strut Mounted Clamp	Figure B2000 by B-Line with B1999 Vibra Cushion

Fabricated steel bracket for strut mounting	Adjustable Strut Bracket	Figure 3064 by B-Line
360 degrees with galvanized steel jacket	Calcium Silicate Shield	Figure B3380-B3384 by B-Line

C. Chemical Piping Systems:
   1. All pipe supports and fasteners shall be glass fiber-reinforced plastic with a flame spread rating of 25, in accordance with ASTM E 84.
   2. Materials shall be manufactured by either the pultrusion or extrusion process.
   3. All pipe supports shall have a surface veil over 100 percent of the surface which, along with a filler system, shall protect against degradation from ultra-violet light.
   4. All fasteners shall be manufactured from long glass fiber-reinforced polyurethane to ensure strength and corrosion resistance.
   5. All-thread rods shall be made from vinylester resin.
   6. Manufacturers: Provide products of one of the following:
      a. Unistrut Company.
      b. Or equal.

2.3 ACCESSORIES

A. Hanger rods shall be made from ASTM A 575, with square head nut on top and running thread on bottom end.

B. Concrete Inserts:
   1. Concrete inserts shall be MSS SP 58 malleable Type 18.
   2. Concrete inserts shall be specified in Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

C. Steel Beam Clamps:
   1. Steel beam clamps shall be of malleable iron and conform to MSS SP 58 Type 21.

D. Inserts for Pipe Insulation:
   1. Insulated pipe, larger than 1-1/2-inches in diameter, shall be supported by a rigid insert to protect the insulation. A steel metal saddle of sufficient gauge to carry the weight of the pipe and its fluid without deforming shall extend 2-inches minimum on each side of the rigid insert. The joints between insert and insulation shall be sealed before saddle is installed. Sizes up to 6-inches IPS shall be MSS SP 58, Type 40, and for sizes over 10-inches shall be MSS SP 58, Type 39.

E. Brackets:
   1. Brackets for wall mounting shall conform to MSS SP-58 as follows:
      a. Medium Duty Welded Steel Brackets: Type 32.

b. Heavy Duty Welded Steel Bracket: Type 33.
c. Side Beam Support: Type 34.

2. Heavy Duty: Forged steel conforming to Federal Specification WW-H-171C, Type 28, Grinnell Figure 292, Size 2 or equal.

F. Pipe Roll:
1. To provide for pipe expansion, pipe shall be supported on adjustable malleable or steel pipe rolls.

G. Fabricated Pipe Rack:
1. Pipes shall be supported and anchored to the fabricated pipe rack as shown. Clamps, rollers, and supports for piping shall conform to the general requirements of MSS SP 69.

2.4 PAINTING

A. Clean and prime ferrous metal surfaces in the shop in accordance with the requirements of Section 09910, Painting.

B. Field painting shall conform to the requirements of Section 09910, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate hangers, supports, and accessories to support piping, valves, and at all concentrated loads.

B. Locate hangers, supports, and accessories within maximum span lengths specified to support continuous pipeline runs unaffected by concentrated loadings.

C. Locate hanger, supports to prevent vibration or swaying and to provide for expansion and contraction.
1. Temperature differential specified in this Section.
2. Support piping independently so that equipment is not stressed by piping weight or expansion.
3. For Uninsulated Copper Pipe or Tubing: Clamps and supports, electroplated copper finish. Instrumentation tubing shall be supported in steel or aluminum troughs with covers. All tubing layout and connections shall be as approved by the manufacturer of the equipment.
4. Uncoated Hangers, Rods and Supports: Dip in zinc chromate primer before installation.
5. Maximum spacing for horizontal piping:
a. Steel 1-Inch and Smaller: Seven feet.
b. Steel 1-1/2-Inch and Larger: Ten feet.

c. Brass or Copper 3-Inch and Smaller: Seven feet.
d. Brass or Copper 4-Inch and Larger: Ten feet.
e. Additional supports at:
   1) Change in direction.
   2) Branch piping and runouts over five feet.
   3) Concentrated loads due to valves, strainers or other similar items.
f. Maximum support spacing for plastic pipe at ambient temperature shall be one-half the above values.

6. Hanger types for horizontal piping, except as noted and shown:
   a. Forged steel adjustable clevis type, rod support for all services.
   b. Slide Bases:
      1) Pipe stand, brackets, trapeze or other equivalent structural support.
      2) For piping 2-inches or larger.
   c. For pipe and covering provide:
      1) Saddles for rollers or slide bases.
      2) Protective shields or saddles for all other types of supports.
   d. Threaded Steel Rods:
      1) Two inch vertical adjustment with two nuts each end for positioning and locking.
      2) Size hanger rods according to the schedule below, unless otherwise noted:

Nominal Pipe (Inches)	Rod Diameter (Inches)
2 and less	3/8
2-1/2 to 3-1/2	1/2
4	5/8
6	3/4
8 through 12	7/8
14 through 18	1
20 through 30	1-1/4

      3) For Double Rod Hangers: One size smaller than above.
      4) Connection to Structure for Piping to 2-Inches: Concrete inserts, or expansion shields in shear into sides of beams.
      5) Connection to Structure for Piping 2-1/2-Inch or Larger: Concrete inserts, beam clamps or suitable bridging.

7. Vertical Piping:
   a. Base Support: Base elbow or welded equivalent.
      1) Bearing plate on structural support.
   b. Guides not to exceed:
      1) 25 feet for piping to 2-inches.
      2) 36 feet for piping 2-1/2-inches or larger.
   c. Top Support:
      1) Special hanger or saddle in horizontal connection.
      2) Provisions for expansion.

d. Intermediate Supports: Steel pipe clamp at floor.
    1) Bolted and welded to pipe.
    2) Extension ends bearing on structural steel or bearing plates.
e. For Multiple Pipes: Coordinate guides, bearing plates and accessory steel.

8. Insulated Piping:
    a. Horizontal Pipe Shields at Supports:
        1) Minimum 120 degree arc.
        2) Length equal to diameter of insulation 12-inch minimum.
        3) To 6-Inch Pipe Size: No. 18 USSG galvanized steel.
    b. Vertical Pipe Shields at Guides:
        1) Full 360 degree arc, securely banded.
        2) Length equal to diameter of insulation, 12-inch minimum.
        3) To 6-Inch Pipe Size: No. 18 USSG galvanized steel.

D. Install items to be embedded before concrete placement.

E. Fasten embedded items securely to prevent movement during concrete placement.

F. Install hangers and support units on piping systems in accordance with manufacturer's recommendations.

G. Adjust hangers and supports and place grout for concrete supports to bring pipelines to specified elevations.

H. Bring all pipe systems up to operating pressures and temperatures. Cycle systems to duplicate operating conditions. Correct all support malfunctions.

+ + END OF SECTION + +

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SECTION 15058

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 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.

1.3 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.

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.
   1. Comply with NEMA MG 1 unless otherwise indicated.
   2. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) 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. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. 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.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

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

Not Applicable

+ + END OF SECTION + +

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SECTION 15061

DUCTILE IRON PIPE

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish ductile iron pipe and fittings.
   2. Extent of piping is shown on the Drawings. Piping schedules in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation, specify pipe service, diameter, material, lining, coating, pressure rating, joint type, and testing required.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before ductile iron pipe Work.

C. Related Sections:
   1. Section 02300, Earthwork.
   2. Section 02505, Pipe Embedment and Backfill Materials
   3. Section 09910, Painting.
   4. Section 15051, Buried Piping Installation.
   5 Section 15052, Exposed Piping Installation.
   6. Section 15055, Pipe Hangers and Supports.
   7. Section 15120, Piping Specialties and Accessories.
   8. Section 15121, Wall Pipes, Floor Pipes and Pipe Sleeves.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ANSI B18.2.1, Square and Hex Bolts and Screws Inch Series.
   2. ANSI B18.2.2, Square and Hex Nuts. (Inch Series).
   3. ASTM A193, Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service.
   4. ASTM A194, Specification for Carbon Steel and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.
   5. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   6. ASTM A354, Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.
   7. ASTM A563, Specification for Carbon and Alloy Steel Nuts.

8. ASTM B117, Practice for Operating Salt Spray (Fog) Apparatus.
9. ASTM C283, Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
10. ASTM D714, Test Method for Evaluating Degree of Blistering of Paints.
11. ASTM D792, Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
12. ASTM D5162, Discontinuity (Holiday) Testing of Non-Conductive Protective Coating on Metallic Substrates.
13. ASTM E96, Test Methods for Water Vapor Transmission of Materials.
14. ASTM G14, Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test).
15. ASTM G62, Test Methods for Holiday Detection in Pipeline Coatings.
16. ASTM G95, Test Methods for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method).
17. ANSI/AWWA C104, Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water.
18. ANSI/AWWA C110, Ductile Iron and Gray Iron Fittings for Water.
19. ANSI/AWWA C111, Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings.
20. ANSI/AWWA C115, Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges.
21. ANSI/AWWA C116, Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile Iron and Gray Iron Fittings for Water Service.
22. ANSI/AWWA C151, Ductile Iron Pipe, Centrifugally Cast, for Water.
23. ANSI/AWWA C153, Ductile Iron Compact Fittings, 3 inch through 24 inch and 54 inch through 64 inch for Water Service.
24. ANSI/AWWA C606, Grooved and Shouldered Type Joints.
25. European Standard (EN), EN 598: Ductile Iron Pipe, Fittings, Accessories and Their Joints for Sewerage Applications.
26. MSS-SP 60, Connecting Flange Joint Between Tapping Sleeves and Tapping Valves.
27. NACE RP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
28. NAPF 500-03, Surface Preparation Standard for Ductile Iron Pipe and Fittings Receiving Special External Coatings and/or Special Internal Linings.
29. NSF/ANSI 61, Drinking Water System Components - Health Effects.
30. SSPC PA 2, Measurement of Dry Coating Thickness with Magnetic Gages.
31. SSPC Painting Manual, Volume 1, Para. XIV.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Manufacturer shall have a minimum of five years successful experience producing ductile iron pipe and fittings and shall be able to show evidence

of at least five installations in satisfactory operation in the United States that are similar applications to the specified service.

b. Lining and coating products shall be manufactured by a firm with a minimum of five years successful experience in protecting pipelines exposed to the specified service conditions , and shall be able to show evidence of at least five installations in satisfactory operation in the United States that are similar applications to the specified service.

c. When not applied by the manufacturer, lining and coating Subcontractor shall have a minimum of five years successful experience in the application of the specified linings and coatings for similar applications for the specified service, and shall be able to show evidence of at least five installations in satisfactory operation in the United States.

B. Supply and Compatibility:

1. Unless otherwise approved, obtain all pipe, fittings, and appurtenances included in this Section from a single ductile iron pipe manufacturer.
2. Ductile iron pipe manufacturer shall review and approve or prepare all Shop Drawings and other submittals for pipe, fittings, and appurtenances furnished under this Section.
3. Pipe, fittings, and appurtenances shall be suitable for the specified service and shall be integrated into overall piping system by ductile iron pipe manufacturer.
4. Ductile iron pipe manufacturer shall be responsible for all products and all factory-applied linings and coatings, whether installed at pipe manufacturer's facility or at manufacturer's Supplier's facility.

C. Regulatory Requirements:

1. Pipe and fittings, including linings and coatings, that will convey potable water or water that will be treated to become potable, shall be certified by an accredited organization in accordance with NSF/ANSI 61 as being suitable for contact with potable water, and shall comply with requirements of authorities having jurisdiction at Site.

1.4 SUBMITTALS

A. Action Submittals: Submit the following with Shop Drawings required under Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation:

1. Shop Drawings:
   a. Detailed drawings and data for pipe, fittings, gaskets, appurtenances, linings, and coatings.

B. Informational Submittals: Submit the following:

1. Certificates:
   a. Submit certificate signed by manufacturer of each product that product conforms to applicable referenced standards and the Contract Documents.
   b. Submit certificate signed by applicator of the linings and coatings stating

that product to be applied conforms to applicable referenced standards and that the applicator shall conform to the Contract Documents.

2. Source Quality Control Submittals:
    a. Submit results of specified shop tests for pipe, fittings, linings, and coatings.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

PART 2 – PRODUCTS

2.1 MATERIALS

A. General:
    1. Piping systems shall be suitable for their intended use.
    2. Joints shall be as specified in Section 15051, Buried Piping Installation and Section 15052, Exposed Piping Installation. If not specified, provide flanged joints for exposed piping and push-on or mechanical joints for buried piping. Provide couplings on pipe with plain or grooved ends where shown or where approved by ENGINEER.

B. Ductile Iron Pipe, Joints, and Fittings:
    1. Flanged Pipe: Fabricate in accordance with ANSI/AWWA C115.
        a. Pressure Rating: As specified in piping schedule in Section 15052, Exposed Piping Installation. If not otherwise specified, use Special Thickness Class 53 for three-inch to 54-inch diameter pipe and Pressure Class 350 for 60-inch and 64-inch diameter pipe.
    2. Non-Flanged Pipe: Conform to ANSI/AWWA C151 for material, pressure, dimensions, tolerances, tests, markings, and other requirements.
        a. Pressure Class: As specified in piping schedules in Section 15051, Buried Piping Installation and Section 15052, Exposed Piping Installation. If not otherwise specified, use Pressure Class 350.
        b. Special Thickness Class: As specified in piping schedules in Section 15051, Buried Piping Installation and Section 15052, Exposed Piping Installation.
    3. Pipe Joints:
        a. Flanged Joints: Conform to ANSI/AWWA C110 and ANSI/AWWA C111 capable of meeting the pressure rating or special thickness class, and test pressure specified in piping schedule in Section 15052, Exposed Piping Installation.
            1) Gaskets: Unless otherwise specified, gaskets shall be at least 1/8-inch thick, ring or full-face as required for the pipe, of synthetic rubber compound containing not less than 50 percent by volume nitrile or

neoprene, and shall be free from factice, reclaimed rubber, and other deleterious substances. Gaskets shall be suitable for the service conditions specified, specifically designed for use with ductile iron pipe and fittings.

2) Bolts: Comply with ANSI B18.2.1.
   a) Exposed: ASTM A307, Grade B.
   b) Buried or Submerged: ASTM A193, Grade B8M, Class 2, Heavy hex, Type 316 stainless steel.
3) Nuts: Comply with ANSI B18.2.2.
   a) Exposed: ASTM A563, Grade A, Heavy hex.
   b) Buried or Submerged: ASTM A194, Grade B8M, Heavy hex, Type 316 stainless steel.

b. Mechanical Joints: Comply with ANSI/AWWA C111 and ANSI/AWWA C151, capable of meeting pressure rating or special thickness class, and test pressure specified in piping schedules in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
   1) Glands: Ductile iron.
   2) Gaskets: Plain tip.
   3) Bolts and Nuts: High strength, low alloy steel.
   4) Manufacturers: Provide products of one of the following:
      a) Clow Water Systems, a Division of McWane, Inc.
      b) American Cast Iron Pipe Co.
      c) U.S. Pipe and Foundry Co.
      d) Or equal.

c. Push-On Joints: Comply with ANSI/AWWA C111 and ANSI/AWWA C151, capable of meeting pressure class or special thickness class, and test pressure specified in piping schedules in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
   1) Gaskets: Vulcanized SBR, unless otherwise specified.
   2) Stripes: Each plain end shall be painted with a circular stripe to provide a guide for visual check that joint is properly assembled.
   3) Products and Manufacturers: Provide one of the following:
      a) Tyton or Fastite Joint by Clow Water Systems.
      b) Fastite Joint by American Cast Iron Pipe Company.
      c) Tyton Joint by U.S. Pipe and Foundry Company.
      d) Or equal.

d. Grooved End Joints: Comply with ANSI/AWWA C606.
   1) Gaskets: Flush seal type designed for ductile iron that complies with or exceeds requirements of ASTM D2000
   2) Bolts and nuts: As specified for flanged joints.
   3) Unless otherwise specified, grooved end couplings shall be rigid joint for exposed service and flexible joint for buried service.
   4) Products and Manufacturers: Provide one of the following:
      a) Victaulic, Style 31.
      b) Or equal.

e. Restrained Joints: Restrained push-on joints shall be capable of being

deflected after full assembly. Field cuts of restrained pipe are not allowed without approval of ENGINEER.

1) Products and Manufacturers: Provide restrained joints for mechanical joint piping by one of the following:
   a) Megalug, Series 1100, by EBBA Iron Sales, Inc.
   b) MJ Coupled Joint, by American Cast Iron Pipe Co.
   c) MJ Field Lok, by U.S. Pipe and Foundry Co.
2) Products and Manufacturers: Provide restrained joints for push-on joint piping by one of the following:
   a) Super-Lock Joint Pipe, by Clow Water Systems, a division of McWane, Inc.
   b) Lok-Ring Joint, or Flex-Ring Joint, by American Cast-Iron Pipe Company.
   c) TR Flex Joint, by U.S. Pipe and Foundry Company.
   d) Snap-Lok, by Griffin Pipe Products Company.
   e) Or equal.

4. Flanged and Push-On Joint Fittings: Comply with ANSI/AWWA C110 and ANSI/AWWA C115.
   a. Material: Ductile iron.
   b. Pressure rating, gaskets, bolts, and nuts shall be as specified for flanged joints. Pressure rating of fittings shall meet, but not exceed, specified pressure rating or special thickness class of the connected pipe.
5. Mechanical Joint Fittings: Comply with ANSI/AWWA C110.
   a. Material: Ductile iron.
   b. Glands: Ductile iron.
   c. Pressure rating, gaskets, bolts, and nuts shall be as specified for mechanical joints. Pressure rating of fittings shall meet, but not exceed, specified pressure rating or special thickness class of connected pipe.

C. Lining, General:
   1. Surface Preparation:
      a. Surface Preparation: Prepare surface in accordance with recommended method.

D. Cement-mortar Lining:
   1. Where specified in piping schedules included with Section 15051, Buried Piping Installation and Section 15052, Exposed Piping Installation, pipe and fittings shall be lined with bituminous seal coated cement-mortar lining in accordance with ANSI/AWWA C104.

E. Couplings:
   1. Refer to Section 15120, Piping Specialties and Accessories.

F. Specials:
   1. Transition Pieces:
      a. Provide suitable transition pieces (adapters) for connecting to existing

piping.

b. Unless otherwise shown or indicated, expose existing piping to determine material, dimensions, and other data required for transition pieces.

2. Taps:

a. Provide taps where shown or required for small-diameter piping or instrumentation connections.

b. Provide corporation stops where shown or required.

c. Where pipe wall thickness or tap diameter will not allow engagement of three full threads, provide tapping saddle with outlet joints conforming to requirements of Paragraph 2.1.B.3.a of this Section for four-inch through 12-inch diameter pipe, and Paragraph 2.1.B.3.b. for 14-inch through 54-inch diameter pipe.

d. For flanged connections on tapping saddle outlet branch, counterbore flange in accordance with MSS SP-60 dimensions. Inside diameter of outlet shall be 1/4-inch greater than nominal diameter.

2.2 MARKING FOR IDENTIFICATION

A. In addition to identification markings specified in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation, also stamp, mark, and identify push-on joint and mechanical joint pipe with:

1. Name or trademark of manufacturer.
2. Weight, class or nominal thickness, and casting period.
3. Country where cast.
4. Year the pipe was produced.
5. Letters “DI” or “Ductile” shall be cast or metal stamped

B. In addition to identification markings specified in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation, also stamp, mark, and identify flanged pipe with:

1. Flange manufacturer’s mark, size, and letters “DI” cast or stamped on the flanges.
2. Fabricator’s mark if other than flange manufacturer.
3. Length and weight.

C. In addition to identification markings specified in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation, also stamp, mark, and identify fittings with:

1. Manufacturer’s identification.
2. Pressure rating.
3. Nominal diameters of openings.
4. Country where cast.
5. Number of degrees or fraction of the circle on bends.
6. Letters “DI” or “Ductile” cast on them.

2.3 EXTERIOR SURFACE PREPARATION AND COATINGS

A. General Coating Requirements:
   1. Coating types are specified in piping schedules in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

B. Exposed Pipe and Fittings:
   1. Surface Preparation:
      a. Initial Surface Inspection: Pipe and fitting manufacturer and coating applicator shall inspect surface to be coated and mutually determine recommended NAPF 500-03 surface preparation method.
      b. Surface Preparation: Prepare surface in accordance with recommended NAPF 500-03 method.
      c. Finished Surface Inspection: Prepared surfaces shall be inspected by coating applicator prior to application to determine acceptability of finished surface. If surface is unacceptable, repeat surface preparation and re-application as necessary.
   2. After recommended surface preparation, prime coat exterior ferrous metal surfaces of pipe and fittings in the shop in accordance with Section 09910, Painting.
   3. Field painting shall comply with Section 09910, Painting.

C. Buried Pipe and Fittings:
   1. Asphaltic Coating: Where specified in piping schedule in Section 15051, Buried Piping Installation, coat pipe and fittings with an asphaltic coating approximately one-mil thick, in accordance with ANSI/AWWA C151, ANSI/AWWA C115, ANSI/AWWA C110, and ANSI/AWWA C153, as applicable.

PART 3 – EXECUTION

3.1 INSPECTION

A. Inspect piping to assure that piping is free from defects in material and workmanship. Verify compatibility of pipe, fittings, gaskets, linings, and coatings.

3.2 INSTALLATION AND FIELD QUALITY CONTROL

A. For buried piping installation and testing, refer to Section 15051, Buried Piping Installation.

B. For exposed piping installation and testing, refer to Section 15052, Exposed Piping Installation.

+ + END OF SECTION + +

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SECTION 15062

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Fiberglass pipe hangers.
   4. Metal framing systems.
   5. Fiberglass strut systems.
   6. Thermal-hanger shield inserts.
   7. Fastener systems.
   8. Pipe stands.
   9. Equipment supports.

B. Related Sections:
   1. Division 5 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
   3. Division 15 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
   4. Division 15 Section(s) "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 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, including pipe stands, 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.
   3. Design seismic-restraint hangers and supports for piping and.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Metal framing systems.
   3. Fiberglass strut systems.
   4. Pipe stands.
   5. Equipment supports.

C. 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.
   1. Detail fabrication and assembly of trapeze hangers.
   2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 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 stainless 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:
1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

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 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:
1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
2. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass or polyurethane.

B. Strap-Type, Fiberglass Pipe Hangers:
1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

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. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.
   c. Flex-Strut Inc.
   d. GS Metals Corp.
   e. Thomas & Betts Corporation.
   f. Unistrut Corporation; Tyco International, Ltd.
   g. Wesanco, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6 Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
7. Metallic Coating: Electroplated zinc.
8. Paint Coating: Vinyl.
9. Plastic Coating: PVC.

B. Non-MFMA Manufacturer Metal Framing Systems:
   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. Anvil International; a subsidiary of Mueller Water Products Inc.
      b. Empire Industries, Inc.
      c. ERICO International Corporation.
      d. Haydon Corporation; H-Strut Division.
      e. NIBCO INC.
      f. PHD Manufacturing, Inc.
      g. PHS Industries, Inc.
   2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
   3. Standard: Comply with MFMA-4.
   4. Channels: Continuous slotted steel channel with inturned lips.
   5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.5 FIBERGLASS STRUT SYSTEMS

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. Allied Tube & Conduit.
   2. Champion Fiberglass, Inc.
   3. Cooper B-Line, Inc.
   4. SEASAFE, INC.; a Gibraltar Industries Company.

B. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
   1. Channels: Continuous slotted fiberglass or other plastic channel with inturned lips.
   2. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   3. Hanger Rods: Continuous-thread rod, nuts, and washer made of fiberglass.

2.6 THERMAL-HANGER SHIELD INSERTS

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. Carpenter & Paterson, Inc.
   2. Clement Support Services.
   3. ERICO International Corporation.
   4. National Pipe Hanger Corporation.
   5. PHS Industries, Inc.
   6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
   7. Piping Technology & Products, Inc.
   8. Rilco Manufacturing Co., Inc.
   9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa), ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.7 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.

2.8 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:
   1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   2. Base: Stainless steel.
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:
   1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   2. Bases: One or more; plastic.
   3. Vertical Members: Two or more protective-coated-steel channels.
   4. Horizontal Member: Protective-coated-steel channel.
   5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.9 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.10 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, non-shrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi (34.5-MPa), 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. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) 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.

H. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 7 Section "Roof Accessories" for curbs.

I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. 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.

P. 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 (DN 100) 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 (DN 100) 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 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. 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 (40 mm).

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 (0.05 mm).

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 painting Sections.

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 metal framing systems and attachments for general service applications.

F. Use fiberglass pipe hangers and fiberglass strut systems and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. 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 (DN 15 to DN 750).
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
   5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
   6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
   7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
   8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
   9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
   10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
   11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
   12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. 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 (DN 24 to DN 600).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

. L. 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 (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

M. 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. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
   8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
   9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
   10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
   11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
   12. 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 (340 kg).
      b. Medium (MSS Type 32): 1500 lb (680 kg).
      c. Heavy (MSS Type 33): 3000 lb (1360 kg).
   13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
   14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
   15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. 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.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. 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.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

+ + END OF SECTION + +

SECTION 15063

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Fiberglass pipe hangers.
   4. Metal framing systems.
   5. Fiberglass strut systems.
   6. Thermal-hanger shield inserts.
   7. Fastener systems.
   8. Pipe stands.
   9. Pipe positioning systems.
   10. Equipment supports.

B. Related Sections:
   1. Division 5 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Division 13 fire-suppression piping Sections for pipe hangers for fire-suppression piping.
   3. Division 15 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.
   4. Division 15 Section "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 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 plumbing 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, including pipe stands, 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.
   3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Metal framing systems.
   3. Fiberglass strut systems.
   4. Pipe stands.
   5. Equipment supports.

C. 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.
   1. Detail fabrication and assembly of trapeze hangers.
   2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 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 (Not in Disinfection/Pump Rooms and Associated Corridors):
   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. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

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 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:
   1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
   2. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass.

B. Strap-Type, Fiberglass Pipe Hangers:
   1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
   2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

2.4 FIBERGLASS STRUT SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Allied Tube & Conduit.
   2. Champion Fiberglass, Inc.
   3. Cooper B-Line, Inc.
   4. SEASAFE, INC.; a Gibraltar Industries Company.

B. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
   1. Channels: Continuous slotted fiberglass channel with inturned lips.

2. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of fiberglass.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.6 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, zinc-coated 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.

2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.9 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, non-shrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi (34.5-MPa), 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. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) 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.

H. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. See Division 15 plumbing fixture Sections for requirements for pipe positioning systems for plumbing fixtures.

I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. 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.

P. 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 (DN 100) 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 (DN 100) 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 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. 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 (40 mm).

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 (0.05 mm).

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 painting Sections.

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, metal trapeze pipe hangers, and attachments for general service applications.

F. Use fiberglass pipe hangers, fiberglass strut systems, and corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. 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 (DN 15 to DN 750).
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
   5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
   6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
   7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
   8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
   9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
   10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).

11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. 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 (DN 24 to DN 600).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

L. 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 (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

M. 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. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. 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 (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. 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.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
   3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
   4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
   5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
   6. 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.
   7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
   8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
      a. Horizontal (MSS Type 54): Mounted horizontally.
      b. Vertical (MSS Type 55): Mounted vertically.
      c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

S. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

+ + END OF SECTION + +

SECTION 15067

THERMOPLASTIC PIPE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install thermoplastic piping and fittings.
   2. Extent of piping is shown and shall be in accordance with piping schedules in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before thermoplastic piping Work.
   2. Notify other contractors in advance of installation of thermoplastic piping to provide them with sufficient time for installing items included in their contracts that must be installed with or before the thermoplastic piping Work.

C. Related Sections:
   1. Section 15051, Buried Process Piping Installation.
   2. Section 15052, Exposed Process Piping Installation.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. AASHTO, Policy on Geometric Design of Highways and Streets.
   2. ASTM D1784, Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
   3. ASTM D1785, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   4. ASTM D2464, Specification for Threaded Poly (Vinyl Chlorinated) (PVC) Plastic Pipe Fittings, Schedule 80.
   5. ASTM D2466, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   6. ASTM D2467, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   7. ASTM D2564, Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.

8. ASTM D2665, Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
9. ASTM D683, Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
10. ASTM D3034, Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
11. ASTM D3035, Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
12. ASTM D3139, Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
13. ASTM D3212, Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
14. ASTM D3311, Specification for Drain, Waste and Vent (DWV) Plastic Fittings Patterns.
15. ASTM F437, Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
16. ASTM F438, Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
17. ASTM F439, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
18. ASTM F441/F441M, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
19. ASTM F442/F442M, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR).
20. ASTM F477, Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
21. ASTM F656, Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
22. ASTM F679, Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
23. ASTM F1336, Specification for Poly (Vinyl Chloride) (PVC) Gasketed Sewer Fittings.
24. ASTM F1674, Standard Test Method for Joint Restraint Products for Use with PVC Pipe.
25. AWWA C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In.-12 In. (100 mm-300 mm), for Water Transmission and Distribution
26. AWWA C905, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In.-48 In. (350 mm-1,200 mm).
27. AWWA C907, Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 In. Through 12 In. (100 mm Through 300 mm).
28. NSF 14, Plastic Piping Systems Components and Related Material.
29. ANSI/NSF 61, Drinking Water System Components - Health Effects.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer's Qualifications: Manufacturer shall have a minimum of five years experience producing thermoplastic pipe and fittings substantively similar to the materials specified, and shall be able to provide documentation of satisfactory service in at least five completed installations.
   2. Installer's Qualifications:
      a. Engage a single pipe installer who shall be responsible for all thermoplastic pipe Work, and who shall employ only tradesmen with specific skills and experience in the type of Work required.
      b. Installer shall have a minimum of five years experience installing thermoplastic pipe and fittings substantively similar to the materials specified and substantively similar to or larger than the scope of thermoplastic piping Work on the Project, and shall be able to provide documentation of satisfactory experience in at least five completed installations.

B. Component Supply and Compatibility:
   1. Obtain all materials included in this Section, regardless of component Supplier, from a single thermoplastic pipe Supplier. All pipe of each material type shall be furnished by the same manufacturer.
   2. Thermoplastic pipe Supplier shall review and approve to prepare all Shop Drawings and other submittals for all materials furnished under this Section.
   3. Materials shall be suitable for specified service conditions and shall be integrated into overall assembly by thermoplastic pipe Supplier.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings: Submit piping layout Shop Drawings in accordance with Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
   2. Product Data: Submit product data on pipe, fittings, gaskets, hardware, and appurtenances sufficient to demonstrate compliance with the Contract Documents.

B. Informational Submittals: Submit the following:
   1. Certificates: Submit certificate of compliance standards referenced in this Section.
   2. Source Quality Control: When requested by ENGINEER, submit results of source quality control tests.
   3. Qualifications Statements: Submit qualifications of manufacturer and installer when requested by ENGINEER.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

PART 2 - PRODUCTS

2.1 SERVICE CONDITIONS

A. General:
   1. Piping materials shall be suitable for services intended. Refer to piping schedules in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
   2. Pipe shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions, and other defects. Unless otherwise shown or specified, pipe shall be uniform in color, opacity, density, and other physical properties.
   3. Conform to NSF 14.
   4. Buried pipe shall be capable of withstanding external live load, including impact, equal to AASHTO H-20 loading, with cover shown on the Drawings.
   5. Pipe, fittings, and appurtenances in contact with potable water or water that will be treated to become potable shall be certified by an accredited organization in accordance with ANSI/NSF 61 as being suitable for contact with potable water, and shall meet requirements of the regulatory authorities having jurisdiction at the Site.

2.2 POLYVINYL CHLORIDE (PVC) PIPING

A. PVC Pipe - General Applications: Unless otherwise shown or specified, PVC pipe shall conform to the following:
   1. Manufacturers: Provide products of one of the following:
      a. Ipex, Inc.
      b. Spears Manufacturing Company.
      c. Or equal.
   2. Material: Unless otherwise specified, conform to the following:
      a. Type and Grade: Type 1, Grade 1.
      b. Wall Thickness: Schedule 80 conforming to ASTIM D1784 and ASTM D1785, and US Product Service PS 21-70 as having same outside diameter dimension as cast-iron pipe.
      c. Temperature Rating: Rated for temperature to 140 degrees F.
      d. Color: Gray.
   3. Fittings: Type, grade, schedule, and color of fitting shall match the associated pipe.
      a. Solvent Weld: Conform to ASTM D2467.
   4. Joints:
      a. Solvent Weld: Use primer and solvent cement recommended by PVC pipe manufacturer for the application. Primer shall be in accordance with

ASTM F656, and solvent cement shall be in accordance with ASTM D2564.

b. Solvent Weld for Sodium Hypochlorite Pipe: Use silica free glue, IPS WELD-ON 724

B. Buried PVC Gravity Sewer Pipe.

1. Manufacturers: Provide products of one of the following:
   a. Ipex, Inc.
   b. Diamond Plastics Corp.
   c. Or equal.
2. Material:
   a. Pipe shall conform to ASTM D3034.
   b. Wall Thickness and Pipe Stiffness: Pipe stiffness shall be determined in accordance with test methods in ASTM D3034.
      1) Main Line: SDR 35, with minimum ring stiffness of 46 psi.
      2) Service Laterals: SDR 28, with minimum ring stiffness of 90 psi.
3. Fittings:
   a. Injection-molded, gasketed fittings shall conform to ASTM F1336, and ASTM D3034.
   b. Fabricated fittings shall conform to ASTM F1336.
   c. Unless otherwise shown or specified, saddle wyes are unacceptable.
4. Joints:
   a. Provide bell and spigot joints. Bell shall consist of an integral wall section to hold securely in place (and prevent displacement during assembly of joint) elastomeric O-ring gasket.
   b. Jointing lubricant shall be as recommended by pipe manufacturer.
   c. Provide elastomeric gaskets conforming to ASTM F477, and ASTM D3139 or ASTM D3212.

C. PVC Drain, Waste, and Vent (PVC-DWV) Pipe.

1. Manufacturers: Provide products of one of the following:
   a. Chemtrol, as manufactured by Nibco, Inc.
   b. Spears Manufacturing Company.
   c. Or equal.
2. Material: In accordance with ASTM D1784. Unless otherwise shown or specified, PVC-DWV pipe shall be:
   a. Type and Grade: Type 1, Grade 1.
   b. Wall Thickness: Schedule 40.
   c. Color: White.
3. Fittings: Manufactured in accordance with ASTM D2665 and ASTM D3311.
   a. Solvent weld.
   b. Spigot.
4. Joints:
   a. Solvent weld.
   b. Threaded.

2.3 IDENTIFICATION

A. Refer to Section 15051, Buried Process Piping Installation, and Section 15052, Exposed process Piping Installation.

2.4 SOURCE QUALITY CONTROL

A. Shop Tests:
   1. Piping manufacturer shall maintain continuous quality control program.
   2. Where applicable and when requested by ENGINEER, submit results of source quality control tests specified in reference standards.
   3. CPVC plastic molding materials used to manufacture pipe and fittings under this Section shall be tested for conformance with ASTM D1784.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect pipe materials for defects in material and workmanship. Verify compatibility of pipe and fittings.

3.2 INSTALLATION

A. For buried piping installation, refer to Section 15051, Buried Piping Installation.

B. For exposed piping installation, refer to Section 15052, Exposed Piping Installation.

+ + END OF SECTION + +

SECTION 15068

HEAT TRACING SYSTEM FOR PROCESS PIPING

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide labor, materials, equipment and incidentals to furnish and install pipe heat tracing systems to prevent pipes from freezing complete and operational.

B. Related Sections:
   1. Section 15069, Insulation of Process Piping.
   2. Division 16, Electrical.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following except as otherwise shown or specified.
   1. American National Standards Institute, Inc. (ANSI).
   2. Institute of Electrical and Electronic Engineers (IEEE).
   3. National Electrical Manufacturer's Association (NEMA).
   4. National Electrical Code (NEC).
   5. Underwriters Laboratories, Inc. (UL).
   6. Factor Mutual Research Corporation (FM).
   7. American Society of Heating, Refrigeration, Air Conditioning Association (ASHRAE).

B. Field Measurements: Take field measurements where required prior to installation to ensure proper fitting of Work.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's literature, illustrations, specifications, and engineering data.
   2. Drawings showing fabrication methods, assembly, installation details and accessories.
   3. Electric and control wiring diagrams.
   4. Test results from each of the three field tests.
   5. Test procedures for verifying the cable integrity and for verifying operational requirements.

PART 2 – PRODUCTS

2.1 DETAILS OF CONSTRUCTION

A. Heat Tracing Systems:
   1. Type: Self-regulating, designed so that heating cable shall consist of two (2) 16 AWG nickel-copper buss wires embedded in parallel in self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heating cable to be cut to length in the field.
   2. Pipe heat tracing system shall be capable of maintaining the protected pipe at or above 60 degrees F throughout the ambient temperature range of –20 degrees F to 105 degrees F with a process fluid temperature of 50 degrees F during operation and -20 degrees F when operation stops.
   3. Constant wattage heaters shall not be used.
   4. Heating cable shall be rated for a maximum operating temperature of 150°F, 120 VAC. Heating cable selection shall be based on fiberglass insulation thickness according to section 15069 Insulation of Process Piping. Cable make-up shall consist of stranded copper bus wires, self-regulating semi-conductive core, modified polyolefin inner jacket, tinned copper braid and fluoropolymer outer jacket.
   5. In order to conserve energy and to prevent overheating, the heating cable shall have a self-regulating factor of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heating cable output going from 40 degrees F pipe temperature operation to 150 degrees F pipe temperature operation.
   6. The outer jacket of fluoropolymer shall be provided of suitable thickness and corrosion resistant properties to prevent corrosion from the surrounding environment.
   7. Provide ambient sensing thermostatic control for each circuit. Thermostat shall include NEMA 4X enclosure with SP-DT switch rated 22 amps 120/240/480 VAC, stainless steel sensor capillary and sensing bulb.
   8. The heating system shall also include all necessary components for proper installation of each circuit as required. Components shall include, but are not limited to, the following:
      a. Power connection kit with junction box for connecting each heating cable to the power each circuit.
      b. Glass cloth adhesive tape to fix heating cable to pipe. Apply at 1-foot intervals.
      c. End seal kit for termination of heating cable.
      d. Peel-off self-sticking black on yellow labels “Electric Traced.” Labels shall be provided for each 5 ft of pipe.
   9. The heating cable circuit shall be protected by a ground-fault device for equipment protection.
   10. Location of heat tracing system shall be as shown on the Drawings.
   11. Manufacturers (Electric Heat Trace System):
      a. XL-Trace by Raychem Corporation.

b. Or equal.

12. Manufacturers (Pre-assembled Heating Cable):
    a. Gardian by Raychem Corporation.
    b. Or equal.

PART 3 – EXECUTION

3.1 INSPECTION

A. Inspect items immediately upon delivery to site for damage.

B. Each reel of heating cable shall be tested upon arrival. If the reel fails the test, then it shall be returned to the factory at no additional cost to OWNER.

3.2 INSTALLATION

A. Install items in conformance with the Shop Drawings and manufacturer's installation instructions and leave in proper working condition.

B. Provide required mounting and control accessories including bolts, nuts, ties, junction boxes and adhesives.

C. Install heating elements directly against metal pipe before insulation is installed. Install in accordance with manufacturer's instructions.

D. Install thermostat bulb rated for hazardous area directly against pipe that is being heated.

E. Complete electric and control system wiring in compliance with Division 16 and in accordance with manufacturer's written instructions.

3.3 FIELD QUALITY CONTROL

A. Required Manufacturer Services: Retain a qualified representative of the manufacturer to perform the following services:
    1. Equipment Installation:
        a. Oversee installation of the equipment and accessories specified herein.
        b. Inspect the completed installation and note deficiencies.
        c. Be present and assist CONTRACTOR during start-up, adjusting, and field testing of completed installation.
    2. Furnish test forms and procedures for field testing.

3. The manufacturer's representative shall revisit the jobsite as often as necessary until trouble is corrected and the installation is entirely satisfactory to the ENGINEER.

B. Field Testing:
   1. Field test and calibrate equipment to demonstrate to the OWNER's representative that equipment will satisfactorily perform the functions and criteria specified in Part 2.
   2. Submit test procedures to the OWNER for approval prior to testing. The tests shall include the megger test as described in Part 3 of this Section.
   3. Provide test apparatus required at no extra cost to OWNER.
   4. Follow testing procedures recommended by the manufacturer and approved by the ENGINEER.
   5. Cable shall be tested three times:
      a. Test cable reel upon arrival.
      b. Test each section of cable after installation and before insulation is placed.
      c. Test each section of cable after insulation is installed.

C. Training:
   1. Initial Instruction Course: After equipment is fully operational, and before OWNER will assume responsibility for the operation of the equipment, the equipment manufacturers operating specialists shall instruct the OWNER's operating personnel in the care, maintenance and proper operation of the equipment.

D. Manufacturer's Installation Report:
   1. Prepare manufacturer's installation reports and submit within 30 days after completion of field testing and operation instruction. The reports shall be prepared in accordance with the requirements of Section 01781, Operation and Maintenance Data, and shall include the following:
      a. Field testing reports.
      b. Description of installation deficiencies not resolved to the OWNER's satisfaction.
      c. Description of problems or potential problems.
      d. Names of OWNER personnel who attended the operations and maintenance training sessions.
      e. Record copy of materials used for the training sessions including an outline summary of the course.

+ + END OF SECTION + +

SECTION 15069

INSULATION OF PROCESS PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, material, equipment and incidentals as shown, specified and required to furnish and install insulation for all outdoor located piping systems, as shown on the Contract Drawings, with all accessories, including valves and fittings

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the insulation of process piping and equipment Work.

C. Related Sections:

   1. Division 15, Applicable Sections on Pipe Valves

D. General:
   1. All existing insulation in all areas that is damaged or displaced due to Work by CONTRACTOR shall be repaired with materials and procedures identical to the existing insulation.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Society for Testing and Materials, (ASTM).
      a. ASTM C 449/C 449M, Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
      b. ASTM C 547, Specification for Mineral Fiber Pipe Insulation.
      c. ASTM E 84, Test Method for Surface Burning Characteristics of Building Materials.
   2. Federal Specifications, (FS).
      a. FS HH-1-558B, Insulation Blocks, Boards, Blankets, Felts, Sleeving, Pipe Fitting Covering.
      b. FS SS-C-160, Cement, Insulation, Thermal.

   3. National Fire Protection Association, (NFPA).

a. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section, regardless of the component manufacturer, from a single insulation of process piping and equipment manufacturer.
   2. The insulation of process piping and equipment manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall assembly by the insulation of process piping and equipment manufacturer.

C. Regulatory Requirements: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. National Fire Protection Association, (NFPA).
   2. Underwriters' Laboratories, Inc., (UL). Fire hazard ratings to be verified by Underwriters' Laboratories, Inc. label or listing or a certified test report from an approved independent testing laboratory.
   3. Local and State Building Codes and Ordinances:
      a. Uniform Building Code
      b. Uniform Mechanical Code.
      c. Model Energy Code.
   4. Permits: CONTRACTOR shall obtain and pay for all required permits, fees, inspections and approvals by authorities having jurisdiction.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Product Data:
      a. Manufacturers' catalog literature, specifications, and illustrations with the following information:
      b. Thermal properties.
      c. Physical properties.
      d. Fire hazard ratings.
      e. Facing information.
      f. Installation instructions.

g. Jointing recommendations for butt joints and longitudinal seam.

2. Samples:
   a. Fiberglass insulation.
   b. Weatherproof insulation.

B. Informational Submittals: Submit the following:
   1. Supplier Instructions:
      a. Fabrication instructions for pipe fittings and valve insulation and coatings.

1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
   1. Deliver materials to the Site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of that Work.
   2. Material shall be packed and shipped in corrugated carton.

B. Storage and Protection:
   1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
   2. Store all materials in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.
   3. Store material in clean, dry area, out of the weather.
   4. Material shall be tightly covered to protect against dirt, water, mechanical injury or chemical damage.
   5. Material shall remain in original cartons until time of installation.

C. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the Site. CONTRACTOR shall notify ENGINEER, in writing, if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.1 DESIGN CRITERIA

A. Insulation systems including covering, mastics, adhesives, sealers and facings shall have the following fire hazard classifications:
   1. Flame Spread: 25 maximum.
   2. Fuel Contributed: 50 maximum.
   3. Smoke Developed: 50 maximum.

2.2 MATERIALS

A. Fiberglass Insulation:
   1. Type: Heavy-density sectional pipe insulation with vapor barrier and self-sealing lap.
   2. Density: Four pounds per cubic foot.
   3. R-Value Minimum: 4.0 hr.-ft^2-°F/BTU.
   4. Fittings: Molded fiberglass.
   5. Jointing Materials: Manufacturer's recommended adhesives and tape.
   6. Valve Insulation: Miter cut nesting size covering segments of same thickness as pipeline, for insulation of valves.
   7. Products and Manufacturers: Provide one of the following:
      a. Owens Corning Fiberglass Corporation, Fiberglass 25ASJ/SSL.
      b. Certain-Teed Products Corporation, Certain Teed snap-on ASJ-SSL.
      c. Or equal.

B. Process Air Piping Insulation:
   1. Type: Insulation shall be 2-1/2-inch thick semi-rigid fiberglass board with a 0.016-inch thick aluminum all-weather jacket for interior and exterior piping, fittings and valves.
   2. Maximum Thermal Conductivity: 0.30 BTU-in./hr.- ft^2-°F at 100°F mean temperature.
   3. Minimum Compressive Strength: 125 lbf/ ft^2.
   4. Application: Insulation shall be installed on all process air piping, fitting and valves as shown. Insulation for fittings and valves shall be mitered from the same insulation material used on process air piping.
   5. Products and Manufacturers: Provide one of the following:
      a. Owens-Corning Fiberglass Pipe and Tank Insulation.
      b. Insul-Wrap 850 by Insul-Therm.
      c. Or equal.

C. Mechanical Equipment Insulation:
   1. Type: Semi-rigid fiberglass board.
   2. Minimum Thickness: Three-inches.
   3. Insulation Jacket: All service jacket.
   4. Density: Three lbs. per cubic foot.
   5. Fasteners: 3/4-inch by 0.015-inch stainless steel bands.
   6. Wrapping: One-inch wire mesh.
   7. Finish: Two, 1/2-inch thick coats of insulating cement with open weave glass cloth.
   8. Lagging Adhesive:
      a. Products and Manufacturers: Provide one of the following:
         1) Foster Products Division, Sealfast 30-36.
         2) Or equal.

b. Type: Asbestos free, fire retardant coating.
c. References:
1) MIL-A-3361B, Class 1, Grade A.
2) NFPA 90A.

9. Insulating Cement:
a. Products and Manufacturers: Provide one of the following:
1) Ryder Sales: Thermokote 1.
2) Insulation Industries Inc., Smooth Kote.
3) Or equal.
b. Type: Asbestos free, hydraulic setting refractory type insulating cement, non-corrosive to ferrous metals.
c. Reference:
1) ASTM C 449/C 449M.
2) Federal Specification SS-C-160 Type III GRF.

10. Products and Manufacturers: Provide one of the following:
a. Certain-Teed Products Corporation, Snap Wrap.
b. Owens-Corning Fiberglass Corporation, Pipe Wrap.
c. Or equal.

D. Weatherproof Insulation Jacket (for insulated pipes and equipment located outdoor exposed to outside ambient conditions and for indoor exposed PEW piping):
1. Type: Smooth embossed aluminum metal jacket.
2. Thickness: 0.016-inches.
3. Moisture Barrier: Polycraft.
4. Fastening: Pre-formed "Z"-lock seam with 2-inch butt strap with sealant.
5. Bands: 1/2-inch aluminum bands with wing seals.
6. Fittings:
a. Type: Pre-fabricated aluminum fittings.
b. Thickness: 0.016-inches.
7. Manufacturers: Provide products of one of the following:
a. ITW, PABCO – Childers.
b. Or equal.

E. Flexible-Elastomeric Thermal Insulation (for refrigerant piping):
1. Type: Expanded close cell structure elastomeric thermal insulation.
2. Thermal Conductivity: 0.25 Btu-inch/hr. - ft^2-°F.
3. Density: Six lbs. per cubic feet.
4. Products and Manufacturers: Provide one of the following:
a. Halstead Industries, Type "Insul-tube".
b. Or equal.

2.3 SOURCE QUALITY CONTROL

A. Source Quality Control: Perform the following tests and inspections at the factory:
1. Flame spread.

2. Smoke developed.
3. Fuel contributed.

PART 3 - EXECUTION

3.1 INSPECTION

A. Ensure that surfaces of all equipment including pipes, valves, and fittings are clean and dry before applying insulation.

3.2 PREPARATION

A. Ensure that piping and equipment has been tested, inspected and released for application of insulation.

3.3 INSTALLATION

A. Pipe insulation shall be continuous through walls and floor openings, except where walls or floors are required to be firestopped or required to have a fire resisting rating.

B. Where hangers are in direct contact with piping the hanger and supporting rod shall be wrapped with foil-faced blanket insulation and vapor sealed. Hanger rod insulation and vapor barrier shall extend up to the rod a minimum distance equal to the diameter of the pipe.

C. Install insulation so as to make surfaces smooth, even, and substantially flush with adjacent insulation.

D. Follow manufacturer's application instructions for all materials used.

E. Provide insulation protection shields for insulated piping supported by pipe hangers.

F. Install and coat insulation in accordance with the manufacturer's recommendations.

G. After applying initial equipment insulation, wrap equipment and insulation with wire mesh and apply two separate coats of insulating cement. Apply one coat of insulating finish cement. When dry, apply one coat of fire retardant lagging adhesive. Embed a layer of open weave glass cloth overlapping all seams by 2-inches, and finish with a second coat of fire retardant lagging adhesive.

H. Weatherproofing for Outdoor Pipe and Equipment Insulation:
   1. Piping: Apply field applied jacket with moisture barrier around pipe or equipment and slip edge into preformed Z lock position to shed water. Butt next

jacket section leaving approximately 3/8-inch gap. Place preformed 2-inch butt strap with sealant over the seam and secure with 1/2-inch aluminum band and wing seal.

2. Fittings: Apply prefabricated metal fittings identical in composition to pipe jacketing.

3.4 FIELD QUALITY CONTROL

A. Ensure that insulation is dry when installed, and before and during application of any finish.

B. Protection:
   1. All material applied in one day shall have the vapor barrier applied the same day and any exposed ends shall be temporarily protected with a moisture barrier and sealed to the pipe.

3.5 SCHEDULE

A. Refer to Schedule below for minimum thickness of pipe insulation:

Pipe Size (inches)	Minimum Insulation Thickness (inches)
1/2 thru 1:	1
1-1/4 thru 4:	1-1/2
5 and up:	2

Refrigerant Piping:	3/4 thick preformed flexible elastomeric "insul-tube" pipe insulation with vapor barrier and sealing tapes w/weatherproof jacket.
Exterior Piping:	1-1/2 thick w/weatherproof jacket.
Exterior Equipment:	3 thick w/cement and weatherproof jacket.

B. Where part of existing piping is removed, the remaining piping shall be capped watertight and covered with insulation. Any existing piping insulation damaged shall be patched.

+ + END OF SECTION + +

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SECTION 15073

VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Elastomeric hangers.
   2. Spring hangers.
   3. Seismic snubbers.
   4. Restraining braces and cables.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: D.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: See structural plans.
      a. Component Importance Factor: See structural plans.
      b. Component Response Modification Factor: See structural plans.
      c. Component Amplification Factor: See structural plans.
   3. Design Spectral Response Acceleration at Short Periods (0.2 Second): See structural plans.
   4. Design Spectral Response Acceleration at 1-Second Period: See structural plans.

1.5 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details 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. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
   4. Seismic-Restraint Details:
      a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
      b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
      c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproved by ICC-ES, or preapproved by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of 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. Elastomeric Hangers (Piping P-101): 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.

C. Spring Hangers (Piping P-101): Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
   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. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amber/Booth Company, Inc.
   2. California Dynamics Corporation.
   3. Cooper B-Line, Inc.; a division of Cooper Industries.
   4. Hilti, Inc.
   5. Kinetics Noise Control.
   6. Loos & Co.; Cableware Division.
   7. Mason Industries.
   8. TOLCO Incorporated; a brand of NIBCO INC.
   9. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
   1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
   2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
   3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

E. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

F. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

G. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

I. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

J. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

K. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 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.

3.2 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:
   1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches (3.2 mm).
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Piping Restraints:
1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 20 ft (6 m) o.c., and longitudinal supports a maximum of 40 ft (12 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

F. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

G. 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.

H. 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. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 15 Section "Domestic Water Piping" for piping flexible connections.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. 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. Verify snubber minimum clearances.
   9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.5 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 sprint isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

+ + END OF SECTION + +

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SECTION 15074

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Isolation mounts.
   3. Restrained elastomeric isolation mounts.
   4. Housed spring mounts.
   5. Elastomeric hangers.
   6. Spring hangers.
   7. Seismic snubbers.

B. IBC: International Building Code.

C. ICC-ES: ICC-Evaluation Service.

D. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.3 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:
   1. Basic Wind Speed: See Structural plans..
   2. Building Classification Category: See Structural plans..
   3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: D.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: See Structural plans.
      a. Component Importance Factor: See Structural plans.
      b. Component Response Modification Factor: See Structural plans..
      c. Component Amplification Factor: See Structural plans..

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): See Structural plans..
4. Design Spectral Response Acceleration at 1-Second Period: See Structural plans.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details 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. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
      a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 15 Sections for equipment mounted outdoors.
   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
   4. Seismic-Restraint Details:
      a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
      b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to

the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 15 Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and

tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of 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. 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-(6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

C. 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.

D. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
   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. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
5. Kinetics Noise Control.
6. Loos & Co.; Cableware Division.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

D. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

J. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 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.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 7 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:
   1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
   2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
   3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 20 feet (6 m) o.c., and longitudinal supports a maximum of 40 feet (12 m) o.c.
   3. Brace a change of direction longer than 12 feet (3.7 m).

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. 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.

I. 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. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 15 Section "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. 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. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 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 air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 1 Section "Demonstration and Training."

+ + END OF SECTION + +

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SECTION 15076

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Stencils.
   5. Valve tags.
   6. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Material and Thickness: Aluminum, 0.032-inch (0.8-mm) 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 (64 by 19 mm).
   3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), 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, 1/8 inch (3.2 mm) 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 (71 deg C).
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
   6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), 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 (A4) 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 (3.2 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), 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. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover 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 (38 mm) high.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
   1. Tag Material: Aluminum, 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: 4 by 7 inches (100 by 178 mm).
   2. Fasteners: Reinforced grommet and wire or string.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

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 9 Section " Interior Painting."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.
   1. Identification Paint: Use for contrasting background.
   2. Stencil Paint: Use for pipe marking.

C. 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 (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:
   1. Low-Pressure, Compressed-Air Piping:
      a. Background Color: White.
      b. Letter Color: Black.
   2. Domestic Water Piping:
      a. Background Color: White.
      b. Letter Color: Black.
   3. Sanitary Waste Piping:
      a. Background Color: White.
      b. Letter Color: Black.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
      a. Cold Water: 2 inches (50 mm), round.
      b. Hot Water: 2 inches (50 mm), round.
      c. Low-Pressure Compressed Air: 2 inches (50 mm), round.
   2. Valve-Tag Color:
      a. Cold Water: White.
      b. Hot Water: White.
      c. Low-Pressure Compressed Air: White.
   3. Letter Color:
      a. Cold Water: Black.
      b. Hot Water: Black.
      c. Low-Pressure Compressed Air: Black.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

+ + END OF SECTION + +

SECTION 15085

PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following plumbing piping services:
   1. Domestic cold-water piping.
   2. Domestic hot-water piping.
   3. Supplies and drains for handicap-accessible lavatories and sinks.

B. Related Sections:
   1. Division 15 Section "Plumbing Equipment Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   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.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
   1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).

2. Jacket Materials for Pipe: 12 inches (300 mm) long by NPS 2 (DN 50).
3. Sheet Jacket Materials: 12 inches (300 mm) square.
4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing 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 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.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation 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 Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA, Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2.2 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, provide one of the following:
      a. Aeroflex USA, Inc.; Aeroseal.
      b. Armacell LLC; Armaflex 520 Adhesive.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
      d. K-Flex USA; R-373 Contact Adhesive.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Dow Corning Corporation; 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; Polyco VP Adhesive.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 SEALANTS

A. Joint Sealants:
   1. Joint Sealants for Cellular-Glass and Phenolic Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
      b. Eagle Bridges - Marathon Industries; 405.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
      d. Mon-Eco Industries, Inc.; 44-05.
      e. Pittsburgh Corning Corporation; Pittseal 444.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
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 (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 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. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.5 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. 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, provide one of the following:
      a. Johns Manville; Zeston.
      b. P.I.C. Plastics, Inc.; FG Series.
      c. Proto 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.

2.6 TAPES

A. 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, provide one of the following:
      a. ABI, Ideal Tape Division; 370 White PVC tape.
      b. Compac Corporation; 130.
      c. Venture Tape; 1506 CW NS.
   2. Width: 2 inches (50 mm).
   3. Thickness: 6 mils (0.15 mm).
   4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   5. Elongation: 500 percent.
   6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

2.7 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Engineered Brass Company.
      b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
      c. McGuire Manufacturing.
      d. Plumberex.
      e. Truebro; a brand of IPS Corporation.
      f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot-water supply and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of 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- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (50 mm) o.c.

a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to 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 (100 mm) 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. Cleanouts.

3.4 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 (50 mm) 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 (50 mm).
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.
1. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints,

seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
   1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
   2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
   3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
   4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. 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.

3.8 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. 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 three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 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.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
   1. NPS 1 (DN 25) and Smaller: Insulation shall be the following:

a. Flexible Elastomeric: 3/4 inch (19 mm) thick.

2. NPS 1-1/4 (DN 32) and Larger: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.

B. Domestic Hot and Recirculated Hot Water:
1. NPS 1-1/4 (DN 32) and Smaller: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
2. NPS 1-1/2 (DN 40) and Larger: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.

C. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet (3 m) of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.

3.12 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. Piping, Concealed:
1. None.

D. Piping, Exposed:
1. None.
2. PVC.

+ + END OF SECTION + +

SECTION 15086

DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following duct services:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, exposed return located in unconditioned space.
   4. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   5. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Related Sections:
   1. Division 15 Section "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
   3. Detail application of field-applied jackets.
   4. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for com-

pliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing 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 agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation 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. 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 II with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      b. Johns Manville; Microlite.
      c. Knauf Insulation; Friendly Feel Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; SOFTR All-Service Duct Wrap.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; Commercial Board.
      b. Fibrex Insulations Inc.; FBX.
      c. Johns Manville; 800 Series Spin-Glas.
      d. Knauf Insulation; Insulation Board.
      e. Manson Insulation Inc.; AK Board.
      f. Owens Corning; Fiberglas 700 Series.

2.2 ADHESIVES

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

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
      d. Mon-Eco Industries, Inc.; 22-25.
   2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
      d. Mon-Eco Industries, Inc.; 22-25.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 SEALANTS

A. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   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 (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 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. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   3. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.5 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.

2.6 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, provide one of the following:
      a. ABI, Ideal Tape Division; 428 AWF ASJ.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
      c. Compac Corporation; 104 and 105.
      d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
   2. Width: 3 inches (75 mm).
   3. Thickness: 11.5 mils (0.29 mm).
   4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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, provide one of the following:
      a. ABI, Ideal Tape Division; 491 AWF FSK.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
      c. Compac Corporation; 110 and 111.
      d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
   2. Width: 3 inches (75 mm).
   3. Thickness: 6.5 mils (0.16 mm).
   4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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, provide one of the following:
      a. ABI, Ideal Tape Division; 370 White PVC tape.
      b. Compac Corporation; 130.
      c. Venture Tape; 1506 CW NS.
   2. Width: 2 inches (50 mm).
   3. Thickness: 6 mils (0.15 mm).
   4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   5. Elongation: 500 percent.
   6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

2.7 SECUREMENTS

A. Insulation Pins and Hangers:
   1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) AGM Industries, Inc.; CHP-1.
         2) GEMCO; Cupped Head Weld Pin.
         3) Midwest Fasteners, Inc.; Cupped Head.
         4) Nelson Stud Welding; CHP.
   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, provide one of the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.

c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).

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, provide one of the following:
1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
2) GEMCO; Peel & Press.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) 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- (0.41-mm) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Products: Subject to compliance with requirements, provide one of 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- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) GEMCO.
2) Midwest Fasteners, Inc.

b. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

2.8 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct 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. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. 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.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 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 (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. 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 (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: 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 (50 mm).

1. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: 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 (50 mm).
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

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 100 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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) 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 (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) 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 (10 deg C) at 18-foot (5.5-m) 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 two times the insulation thickness, but not less than 3 inches (75 mm).
5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) 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- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

B. Board 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 100 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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
    b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
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 (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) 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 (10 deg C) at 18-foot (5.5-m) 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 two times the insulation thickness, but not less than 3 inches (75 mm).
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
    1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. 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 (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) 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.

D. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

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. Fire-stop systems are specified in Division 7 Section "Through-Penetration Firestop Systems."

3.8 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 9 painting Sections.
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. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. 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 the "Duct Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 DUCT INSULATION SCHEDULE, GENERAL

A. 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, round and flat-oval, supply-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

B. Concealed, round and flat-oval, return-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

C. Concealed, round and flat-oval, outdoor-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

D. Exposed, round and flat-oval, supply-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

E. Exposed, round and flat-oval, return-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

F. Exposed, round and flat-oval, exhaust-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

G. Exposed, supply-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

H. Exposed, return-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3.12 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. PVC: 20 mils (0.5 mm) thick.

+ + END OF SECTION + +

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SECTION 15092

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Stack-sleeve fittings.
   3. Sleeve-seal systems.
   4. Sleeve-seal fittings.
   5. Grout.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Smith, Jay R. Mfg. Co.
   2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
   1, Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. CALPICO, Inc.
   3. Metraflex Company (The).
   4. Pipeline Seal and Insulator, Inc.
   5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1. Sealing Elements: NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Plastic.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Presealed Systems.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
   3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 7 Section "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.

2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 7 Section "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6 (DN 150). Cast-iron wall sleeves, sleeve-seal fittings.
2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
    a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
        1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
    a. Piping Smaller Than NPS 6 (DN 150). PVC-pipe sleeves.
5. Interior Partitions:
    a. Piping Smaller Than NPS 6 (DN 150). PVC-pipe sleeves.

+ + END OF SECTION + +

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SECTION 15097

ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, exposed-rivet hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
      f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
      h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with rough-brass finish.
      i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
      j. Bare Piping in Equipment Rooms: One-piece, cast-brass[or split-casting brass]type with rough-brass finish.
      k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type[or split-plate, stamped-steel type with exposed-rivet hinge.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1 New Piping: One-piece, floor-plate type.
   2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

+ + END OF SECTION + +

SECTION 15100

VALVES AND APPURTENANCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install valves, four-inch diameter and larger, and appurtenances, complete and operational.
   2. The Work includes, but is not necessarily limited to, types of valves required for buried, exposed, submerged, and other types of piping except where otherwise specifically included in other Sections.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before valves Work.

C. Related Sections:
   1. Section 09910, Painting.
   2. Section 13453, DeviceNet.
   3. Section 15051, Buried Piping Installation.
   4. Section 15052, Exposed Piping Installation.
   5. Section 15061, Ductile-Iron Pipe.
   6. Section 15066, Copper Pipe.
   7. Section 15067, Thermoplastic Pipe.
   8. Section 15120, Piping Specialties and Accessories.
   9. Section 15121, Wall Pipes, Floor Pipes, and Pipe Sleeves.
   10. Section 15140, Domestic Water Piping.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of 5 years of experience in the production of substantially similar equipment, and shall show evidence of satisfactory service in at least 5 installations.
   2. Each type of valve shall be the product of one manufacturer.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. American Bearing Manufacturers Association (ABMA).
   2. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings.

3. ANSI B16.4, Cast Iron Fittings.
4. ANSI B16.34, Valves-Flanged, Threaded and Welding end. (ASME B16.34).
5. ANSI/NSF 61, Drinking Water Components – Health Effects.
6. API STD 594, Check Valves, Flanged Lug, Wafer and Butt-Welding.
7. API STD 598, Valve Inspection and Testing.
8. API STD 609, Butterfly Valves: Double Flanged, Lug-Type and Wafer-Type.
9. ASTM A126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
10. ASTM A276, Specification for Stainless Steel Bars and Shapes.
11. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
12. ASTM A536, Specification for Ductile Iron Castings.
13. ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
14. ASTM B98/B98M, Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
15. ASTM B138/B138M, Specification for Manganese Bronze Rod, Bar and Shapes.
16. ASTM D429, Test Methods for Rubber Property - Adhesion to Rigid Substrates.
    AWWA C111, Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.
17. AWWA C501, Cast-Iron Sluice Gates.
18. AWWA C502, Dry-Barrel Fire Hydrants.
19. AWWA C504, Rubber-Seated Butterfly Valves.
20. AWWA C507, Ball Valves, 6-inch through 48-inch.
21. AWWA C508, Swing-Check Valves for Waterworks Service, 2-inch through 24-inch NPS.
22. AWWA C509, Resilient-Seated Gate Valves for Water Supply Service.
23. AWWA C540, Power-Actuating Devices for Valve and Slide Gates.
24. AWWA C550, Protective Interior Coatings for Valves and Hydrants.
25. AWWA Manual M49, Butterfly Valves: Torque, Head Loss, and Cavitation Analysis.
26. FS TT-C-494, Coating Compound, Bituminous, Solvent Type, Acid-Resistant.

1.3 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Installation drawings showing orientation of valve in both plan and elevation view. Drawings shall clearly identify valve and its appurtenances, including controls, actuators, valve stems, and other components. Show dimensions of valves and appurtenances in relation to piping and structural and architectural components, where applicable.
      b. Controls for and control characteristics of modulating valves.

c. Power and control wiring diagrams, including terminals numbers for electric-motor actuators.

2. Product Data:
   a. Product data sheets.
   b. Complete catalog information, including dimensions, weight, specifications, and identification of materials of construction of all parts.
   c. Corrosion resistance information to confirm suitability of valve materials for the application. Furnish information on chemical resistance of elastomers from elastomer manufacturer.
   d. Cv values and hydraulic headloss curves.
3. Samples:
   a. If requested by ENGINEER, furnish one foot of chain for chainwheel-operated valves.
4. Testing Plans: Submit plan for shop testing of each valve for which shop testing is specified, including testing plan's and test facility's limitations proposed.

B. Informational Submittals: Submit the following:
1. Certificates:
   a. Certificates of compliance with referenced standards, where applicable, including those of AWWA, NSF, and others required by ENGINEER.
2. Design Data: Submit calculations for the following:
   a. Sizing of electric actuators.
   b. Sizing of operating mechanism with extension stems.
   c. Sizing of gear actuators.
3. Manufacturer Instructions: Submit manufacturer's instructions for handling, storing, and installing valves and appurtenances. Provide templates and setting drawings for valves and appurtenances that require anchor bolts or similar anchorages.
4. Source Quality Control Submittals:
   a. Submit copies of shop test results and inspection data, certified by manufacturer.
5. Field Quality Control Submittals: Submit results of field tests required.
6. Supplier's Reports: When requested by ENGINEER, submit written report of results of each visit to Site by Supplier's serviceman, including purpose and time of visit, tasks performed and results obtained.
7. Qualifications Statements: When requested by ENGINEER, submit manufacturer's qualifications demonstrating compliance with the Specifications, including list of existing installations with contact names and telephone number(s) for each.

C. Closeout Submittals: Submit the following:
1. Operations and Maintenance Data:
   a. Furnish operation and maintenance manuals in accordance with Section 01781, Operation and Maintenance Data.

b. Furnish in operations and maintenance manuals complete nameplate data for each valve and electric actuator.

2. Spare Parts, Extra Stock Materials, and Tools:
   a. Spare Parts and Extra Stock Materials: Furnish as specified for each valve type.
   b. Tools: Furnish two sets of special tools (excluding metric tools, if applicable) for each size and type of valve furnished.

1.4 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Deliver materials and equipment to Site to ensure uninterrupted progress of the Work. Deliver anchorage products that are to be embedded in concrete in ample time to prevent delaying the Work.
   2. Inspect boxes, crates, and packages upon delivery to Site and notify ENGINEER in writing of loss or damage to materials and equipment. Promptly remedy loss and damage to new condition in accordance with manufacturer's instructions.
   3. Conform to Section 01651, Transportation and Handling of Products.

B. Storage and Protection:
   1. Keep products off ground using pallets, platforms, or other supports. Store equipment in covered storage and prevent condensation and damage by extreme temperatures. Store in accordance with manufacturer's recommendations. Protect steel, packaged materials, and electronics from corrosion and deterioration.
   2. Conform to Section 01661, Storage and Protection of Products.

PART 2 - PRODUCTS

2.1 General

A. Valves, General:
   1. Provide each valve with manufacturer's name and rated pressure cast in raised letters on valve body.
   2. Provide valves with brass or Type 316 stainless steel nameplate attached with Type 316 stainless steel screws. Nameplates shall have engraved letters displaying the following minimum information:
      a. Valve size.
      b. Pressure and temperature ratings.
      c. Application (other than water and wastewater).
      d. Date of manufacture.
      e. Manufacturer's name.
   3. Provide valves to turn clockwise to close, unless otherwise specified.

4. Provide valves with permanent markings for direction to open.
5. Manually operated valves, with or without extension stems, shall require not more than 40-pound pull on manual operator to open or close valve against specified criteria. Gear actuator and valve components shall be able to withstand minimum pull of 200 pounds on manual operator and input torque of 300-foot pounds to actuator nut. Manual operators include handwheel, chainwheel, crank, lever, and T-handle wrench.

B. Valve Materials:
1. Valve materials shall be suitable for the associated valve's service or application, as shown.
2. Protect wetted parts from galvanic corrosion caused by contact of different metals.
3. Wetted components and wetted surfaces of valves used with potable water or water that will be treated to become potable shall conform to ANSI/NSF 61.
4. Clean and descale fabricated stainless steel items in accordance with ASTM A380 and the following:
   a. Passivate all stainless steel welded fabricated items after manufacture by immersing in pickling solution of six percent nitric acid and three percent hydrofluoric acid. Temperature and detention time shall be sufficient for removing oxidation and ferrous contamination without etching surface. Perform complete neutralizing operation by immersing in trisodium phosphate rinse followed by clean water wash.
   b. Scrub welds with same pickling solution or pickling paste and clean with stainless steel wire brushes or by grinding with non-metallic abrasive tools to remove weld discoloration, and then neutralize and wash clean.

C. Valve Joints:
1. Exposed Valves: Unless otherwise specified, provide with flanged ends conforming to ANSI B16.1. Pressure class of flanges shall be equal to or greater than specified pressure rating of the associated valve.
2. Buried Valves: Unless otherwise specified, provide with mechanical or push-on joints, restrained or unrestrained, as required by piping with which valve is installed.
3. For stainless steel bolting, except where nitrided nuts are required, use graphite-free anti-seize compound to prevent galling. Strength of joint shall not be affected by using anti-seize compound.

D. Plug Valves:
1. Type 100 – Eccentric Plug Valves (for exposed service):
   a. Type: Nonlubricated eccentric plug with resilient plug faces.
   b. Construction:
      1) Body and Plug Material: Cast iron, ASTM A126, Class B.
      2) Bearings: Noncorrosive, permanently lubricated.
      3) Seat: Nickel or nickel-coated stainless steel.

4) Bushings: Bronze.
5) Plug Facing: Neoprene.
6) Packing: Nitrile-Butadiene, externally adjustable.

c. Pressure Rating:

1) Valves 12-inch Diameter and Smaller: 175 psi, unless otherwise specified in the Valve Schedule.

2) Valves 14-inch to 72-inch Diameter: 150 psi, unless otherwise specified in the Valve Schedule.

d. End Connections: Flanged.
e. Operator: As specified in the Valve Schedule.
f. Manufacturer and Model:
1) DeZurik, Model PEC.
2) Milliken, Series 601RL.
3) Or equal.

2. Type 110 – Eccentric Plug Valves (for buried service):
a. Type: Nonlubricated eccentric plug with resilient plug faces.
b. Construction:
1) Body and Plug Material: Cast iron, ASTM A126, Class B.
2) Bearings: Noncorrosive, permanently lubricated.
3) Seat: Nickel.
4) Bushings: Bronze.
5) Plug Facing: Neoprene.
6) Packing: Nitrile-Butadiene, externally adjustable.
c. Pressure Rating: 150 psi.
d. End Connections: Mechanical Restrained Joint.
e. Operator:
1) As specified in the valve schedule.
2) Furnish completely enclosed mounting bracket and actuator cover for buried valves.
f. Manufacturer and Model:
1) DeZurik, Model PEC.
2) Milliken, Series 601RL.
3) Or equal.

E. Ball Valves:
1. Type 200 – 3-Inch and Smaller, 2-Way; Ball Valves for General Water and Air:
a. Style: Standard ball with circular full port.
b. Construction:
1) Body & End Piece: Bronze
2) Ball: Stainless Hard chrome-plated solid bronze or brass
3) Stem: Blowout-proof.
4) Seat & Packing: PTFE.
c. Operator: Zinc-coated steel hand lever operator with vinyl grip, unless otherwise specified
d. End Connection: Threaded.

e. Pressure Rating: 600-pound WOG, 150-pound SWP
f. Temperature Rating: 0 degrees F to 400 degrees F.
g. Manufacturer and Model:
1) Threaded:
a) Conbraco Apolo; 70-100
b) Nibco; T-580-70
c) or equal
2) Soldered
a) Conbraco Apolo; 70-200
b) Nidco; s-580-70
c) or equal

2. Type 210 – Vee-Ball Valve 1 Inch to 16 Inches:
a. Style: Standard ball with vee port
b. Construction:
1) Body: Type 317 stainless steel
2) Ball: Heat treated nickel or hard chromium-plated Type 317 stainless steel
3) Shaft: Splined-type 17-4 PH stainless steel
4) Seals, Flow-Ring: Reinforced PTFE
5) Sleeve Bearings: Reinforces PTFE with stainless steel or Hastalloy
6) Packing, V-ring: PTFE
c. Operator: As specified, valve shall have 300:1 range ability and equal percentage characteristic
d. End Connection: ANSI Class 150-pound flanged
e. Manufacturer and Model
1) Fisher Controls; Design V150
2) DeZurick; VPB V-Port Ball Valve
3) or equal

3. Type 220 – PVC True Union Ball Valves 2 Inches and Smaller:
a. Style: Standard ball with circular port.
b. Construction:
1) Body, Ball & Stem: ASTM D1784, Type I Grade 1 PVC.
2) Seals: Viton or Teflon O-ring
c. End Connections: Solvent welded.
d. Pressure Rating: 150 psi at 75 degrees F.
e. Operator: Tee Head.
f. Manufacturer and Model:
1) Nibco; Chemtrol Tru-Bloc.
2) ASAHI/America; Type 21
3) Spears; True Union
4) Or equal.

F. Butterfly Valves:
1. Type 300 – Circular, Iron Body Butterfly Valves (for exposed services):
a. Standards: Valves shall conform to AWWA C504.

b. Body Type: Short body, except where otherwise shown or required to obtain required clearance for valve operator or disc.
c. Class: As specified in the Valve Schedule. Class 150B if not specified.
d. Construction:
    1) Body: Cast iron ASTM A126 Class B or Ductile Iron ASTM A 536, Grade 65-45-12.
    2) Disc: Epoxy coated Cast iron ASTM A48 Class 40 or Ductile Iron ASTM A 536, Grade 65-45-12 with 316 Stainless Steel edge.
    3) Shaft: Type 304 stainless steel with V-type or O-ring shaft seals.
    4) Seat: Buna-N rubber seat bonded or molded in body and stainless steel seating surface.
    5) Packing: EPDM.
e. Required Features:
    1) Body shall be completely lined by seat.
    2) Valve shall have no travel stops for disc on interior of body.
    3) Valve shall be suitable for throttling operations and infrequent operation after periods of inactivity.
    4) Valves shall be in full compliance with NSF 61. Provide NSF 61 certificate for each valve.
    5) Valves shall open with a counter-clockwise rotation.
    6) Valve and seat shall be rated for zero leakage at 150 psi differential pressure on isolation and dead end service without the use of downstream flanges.
    7) Valves shall be bubble-tight with rated pressure applied from either side and shall be tested with pressure applied in both directions.
    8) Provide epoxy lining and coating in compliance with AWWA C550.
    9) Elastomer seats which are bonded or vulcanized to the 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.
    10) Proved traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
    11) Metal-to-metal thrust bearing surfaces shall be isolated from the flowstream.
f. End Connections: Flanged ANSI Class 125, unless otherwise shown or specified.
g. Operator: As specified in the Valve Schedule
h. Manufacturer and Model:
    1) Pratt, Model 2FII or Triton XR-70
    2) DeZurik, AWWA Model.
    3) Or equal

2. Type 310 – Circular, Iron Body Butterfly Valves (for buried services):
    a. Standards: Valves shall conform to AWWA C504.
        1) Body Type: Short body, except where otherwise shown or required to obtain required clearance for valve operator or disc.

b. Class: As specified in the Valve Schedule. Class 150B if not specified.
c. Construction:
    1) Body: Cast iron ASTM A126 Class B or Ductile Iron ASTM A 536, Grade 65-45-12.
    2) Disc: Epoxy coated Cast iron ASTM A48 Class 40 or Ductile Iron ASTM A 536, Grade 65-45-12 with 316 Stainless Steel edge.
    3) Shaft: Type 304 stainless steel with V-type or O-ring shaft seals.
    4) Seat: Buna-N rubber seat bonded or molded in body and stainless steel seating surface.
    5) Packing: EPDM.
d. Required Features:
    1) Body shall be completely lined by seat.
    2) Valve shall have no travel stops for disc on interior of body.
    3) Valve shall be suitable for throttling operations and infrequent operation after periods of inactivity.
    4) Valves shall be in full compliance with NSF 61. Provide NSF 61 certificate for each valve.
    5) Valves shall open with a counter-clockwise rotation.
    6) Valve and seat shall be rated for zero leakage at 150 psi differential pressure on isolation and dead end service without the use of downstream flanges.
    7) Valves shall be bubble-tight with rated pressure applied from either side and shall be tested with pressure applied in both directions.
    8) Provide epoxy lining and coating in compliance with AWWA C550.
    9) Elastomer seats which are bonded or vulcanized to the 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.
    10) Proved traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
    11) Metal-to-metal thrust bearing surfaces shall be isolated from the flowstream.
e. End Connections: Mechanical joint, unless otherwise shown or specified.
f. Operator: As specified in the Valve Schedule
g. Manufacturer and Model:
    1) Pratt, Groundhog
    2) DeZurik; Buried AWWA Valve.
    3) Or equal

G. Check Valves:
1. Type 400 –2-inch to 24-inch Swing Check Valves:
    a. Style: Outside lever and weight check valve.
    b. Construction: All materials of construction shall conform to AWWA C508 and shall be as follows:

1) Body, Cover, Disc, Levers: Cast iron, ASTM A126, Class B or ductile iron.
2) Hinge: Ductile Iron
3) Extended Hinge Pin: Stainless Steel.
4) Hinge Pin Bushings: Bronze.
5) Seat Ring: Bronze.
6) Disc Plate: Bronze
7) Disc: Buna-N
8) Disc Holder: Cast Iron A126, Class B
9) Disc Center Pin Assembly: Ductile Iron.
10) Lever Arm: Steel
11) Spring, bracket, eyebolt: Steel
12) All Rubber Items:
    a) Up to 180 degrees F Fluid Temperature: Buna-N.
13) Gland Packing: Graphite.

c. Pressure Rating:
1) 2-inch to 12-inch diameter: 175 psi. WWP
2) 14-inch to 24 inch diameter: 150 psi WWP

d. End Connections: Flanged ANSI Class 125, unless otherwise shown or specified.

e. Required Features:
1) Provide check valves with outside adjustable lever and weight.
2) Valves shall be coated on the interior with fusion-bonded epoxy in accordance with AWWA C550.

f. Manufacturer and Model:
1) M&N Valve; Style 59, 159, or 259
2) Muller co.; No. A-2600 Series.
5) Or equal.

H. Flap Valves:

1. Type 500: Flap Valve:
a. Style: Standard flange framed flap valve
b. Construction:
1) Flap Cover: Cast Iron ASTM A26 Class B
2) Cover Seat Facing: Bronze ASTM B21 C464
3) Body: Cast Iron ASTM A126 Class B
4) Body Seat Facing: Bronze B21-464
5) Hinge Arm: Bronze ASTM B584 C865
6) Hinge Pin & Washers: Stainless Steel A276-304
7) Cotter Pins: Bronze B98 C655

c. Connection: Flap gate shall be mounted to concrete head wall with manufacturer recommended anchor bolts precast in head wall.

d. Required Features:
1) The angel of the cover to vertical, when seated shall be between 2 degrees and 5 degrees from vertical.

2) Each hinge are will have two pivot points, an adjustable lower pivot with limited rotation and a threaded upper hinge post to adjust flap valve sensitivity. A lubrication fitting will be supplied for each pivot.
3) Valve shall be coated with a minimum of 10 mils of amine modified polyamide epoxy Amerlock 400.

e. Manufacturer and Model:
1. Rodney Hunt, Series FV-SPR
2. Or equal.

I. Mud Valves:
1. Type 600 – Mud Valves:
a. Style: Non-rising stem type mud valve.
b. Construction:
1) Frame, Plug and Yoke: Cast iron ASTM A126 Class B.
2) Stem and Stem Nut: Bronze.
3) Disc Ring: Bronze.
4) Seat Ring: Bronze, Resilient.
5) Seat: Seamless molded Buna-N.
c. End Connections: Flanged ANSI Class 125, unless otherwise shown or specified.
d. Manufacturer and Model:
1) Clow, Style F-3075-T
2) Troy Valve, Figure A25600RB.
3) Or equal.

J. Telescoping Valves:
1. Type 700 – Telescoping Valves:
a. Style: Floor mounted rising stem type telescoping valve
b. Construction:
1) Tube and Bail: Type 316 stainless steel, ASTM A240.
2) Bolts, Nuts and Washers; Type 316 stainless steel, ASTM A193, Grade B.
3) Seal Ring: Seamless molded Buna-N.
4) Stem: Type 316 stainless steel.
c. End Connections: Flange with ANSI B16.1, Class 125.
d. Required Features:
1) The tube shall have V-notch weirs for flow control.
2) The length of the tube shall be sufficient to allow the full required travel with not less than 12-inch tube length remaining below the companion flange when the valve is fully raised. The full required travel shall be defined as the distance between the top of the telescoping valve elevation as shown on the Drawings and the companion flange elevation as shown on the Drawings.
e. Manufacturer and Model:

1) Troy
2) Whipps, Inc.
3) Or equal.

K. Backflow Preventer Assemblies:
1. Type 800 – Reduced Pressure Principle Backflow Preventers:
a. Standards: Shall be listed and approved by the F.C.C.C.R.,U.S.C.
b. Construction:
1) Body: Bronze or cast-iron.
2) Valve Discs: Neoprene.
3) Diaphragm: Neoprene coated cotton duck.
c. Maximum Working Pressure: 175 psi.
d. End Connections: Flanged.
e. Accessories:
1) Air gap drain funnel with threaded outlet.
2) Strainer with blow-off on inlet.
3) Outside screw and yoke gate valves on inlet and outlet.
f. The maximum rated flow and the pressure loss shall be stamped legibly on the unit or on a metal label, permanently attached to the unit.
g. Manufacturer and Model:
1) Febco Sales Inc., Model 825YD.
2) Watts Regulator Company, Series 909RPDAOSY.
3) Or equal.

L. Pressure Reducing Valves:
1. Type 900 – Hydraulically Operated Pressure Control Valves
a. Style: Single diaphragm-actuated, pilot controlled self contained type.
b. Construction:
1) Body and Cover: Cast-iron.
2) Piston, Liner and Pilot Valve: Bronze
3) Seat Crown: Bronze (Valves without V-ports and which throttle across the seat shall have stainless steel seats).
4) Piston Cup, and Liner Cup: Buna-N.
5) Seat Washer: Buna-N.
6) Rod, Gland and Bushing
7) Valve Discs: Neoprene.
8) Diaphragm: Neoprene coated cotton duck.
c. Maximum Working Pressure: 175 psi.
d. End Connections: Flanged.
e. Accessories:
1) Air gap drain funnel with threaded outlet.
2) Strainer with blow-off on inlet.
3) Outside screw and yoke gate valves on inlet and outlet.
f. The maximum rated flow and the pressure loss shall be stamped legibly on the unit or on a metal label, permanently attached to the unit.

g. Manufacturer and Model:
    1) Febco Sales Inc., Model 825YD.
    2) Watts Regulator Company, Series 909RPDAOSY.
    3) Or equal.

2. Type 1000 – Pressure Reducing Valves
    a. Manufacturers: Provide products of one of the following:
        1) Cla-Val.
        2) Singer Valve, Inc.
    b. General:
        1) Manufacturer shall submit a schematic of the proposed pilot system with the shop drawings. A direct factory representative shall be made available for start-up service, inspection and necessary adjustments.
        2) Application: Valve shall maintain a constant downstream pressure regardless of changing flow rate and/or inlet pressure.
        3) Rated Working Pressure: 250 psi
        4) Sizing Schedule:

	SBWS-PRV-1	**SBWS-PRV-2**
Maximum Flowrate (gpm)	1,500	1,500
Minimum Flowrate (gpm)	300	300
Maximum Upstream Pressure (psig)	250	150
Minimum Upstream Pressure (psig)	100	80
Maximum Downstream Pressure (psig)	150	75
Minimum Downstream Pressure (psig)	80	15
Setpoint Downstream Pressure (psig)	100	40
Basis of Design Model (CLA-VAL)	90-10	90-10

        5) The valves shall not suffer cavitation damage within a five-year period from the date of installation when exposed to the specified operating conditions.
        6) Anti-cavitation trim shall be provided at a minimum where indicated in the valve schedule (KO), but may be required elsewhere per manufacturer recommendations to meet the design conditions.
    c. Valve Construction:
        1) Type: Pilot operated globe style valves.
        2) Main Valve - The valve shall be hydraulically operated, single diaphragm-actuated, reduced-port where recommended, globe pattern. The valve shall consist of three major components: the body with seat installed, the cover with bearings installed, and the diaphragm assembly. The diaphragm assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve, separating operating pressure from line pressure. Packing

glands and/or stuffing boxes are not permitted and there shall be no pistons operating the main valve or pilot controls.

3) Main Valve Body - No separate chambers shall be allowed between the main valve cover and body. Valve body and cover shall be of cast ductile iron, pressure class 250 psi, with ANSI 150-pound flanged ends. No fabrication or welding shall be used in the manufacturing process.
4) The flow area shall be equal to nominal pipe area when valve is fully open.
5) The valves shall provide a drip-tight shut-off at the rated pressure when closed.
6) Provide a removable flanged cover to access the valve internals.
7) The valve base plugs shall be fitted with nipples and ball valves.

d. Materials of Construction:
   1) Body: Ductile Iron, ASTM A 536.
   2) Trim: Type 316 Stainless Steel.
   3) All Flexible Items: Buna-N, suitable for the application.
   4) All internal and external bolting and other hardware; including pins, set screws, studs, bolts, nuts and washers: Type 316 stainless steel.
   5) Packing: Teflon.
   6) Pilot system piping shall utilize stainless steel braided hose with threaded fittings.
   7) Stem, nut and spring: Type 316 stainless steel.

e. Interior Coating:
   1) All valves shall be coated with fusion bonded epoxy , inside and out. The exterior surfaces shall be epoxy coated in accordance with AWWA C550.

f. Valve Control Accessories
   1) Pilot Control System – The pressure reducing pilot control shall be a direct-acting, adjustable, spring-loaded, normally open, diaphragm valve designed to permit flow when controlled pressure is less than the spring setting. The pilot control shall be held open by the force of the compression on the spring above the diaphragm and shall close when the delivery pressure acting on the underside of the diaphragm exceeds the spring setting. The pressure reducing pilot shall be adjustable from minimum to maximum downstream pressure range listed in the sizing schedule.
   2) The pressure sustaining pilot control shall be a direct-acting, adjustable, spring-loaded control that opens when upstream pressure exceeds the spring setting on the pilot.
   3) The pilot system shall include a hydraulic check feature connected to a second downstream sensing port that will fully close the valve upon pressure reversal.
   4) Provide an indicator rod attached to the piston for visual position indication of the piston.

5) The pilot control piping shall include the following minimum items:
   a) (Closing) speed control, adjustable restriction
   b) (Opening) speed control, adjustable restriction
   c) A pilot valve to adjust the required set point downstream pressure.
   d) A wye strainer with a valved blow-off connection.
   e) Isolation valves.

g. Testing:
   1) Test each assembled valve, except control piping, hydrostatically at 1-1/2 times the rated working pressure for a minimum of five minutes.
   2) Test each valve for leakage at the rated working pressure against closed valve. The test duration shall be minimum 15 minutes and permitted leakage shall be zero.
   3) Perform functional test on each valve to verify specified performance.

M. Tapping Tee and Gate Valve:
   1. Type 1100 – Resilient Seated Gate Valve (for buried pipe tapping):
      a. Standards: Valves shall conform to AWWA 509 with oversized seat rings to permit entry of the tapping machine cutter.
      b. Type: Provide NRS valves for buried service.
      c. Class: 125.
      d. Working pressure 200 psig
      e. Construction:
         1) Body: Ductile Iron ASTM A 536, Grade 65-45-12.
         2) External dome and packing bolts: 316 Stainless Steel
         3) Packing Seal: Buna-N rubber “O” ring
      f. Required Features:
         1) Valve shall be suitable for infrequent operation after periods of inactivity.
         2) Valves shall be in full compliance with NSF 61. Provide NSF 61 certificate for each valve.
         3) Valves shall open with a counter-clockwise rotation.
         4) Valve and seat shall be rated for zero leakage at 200 psi differential pressure on isolation and dead end service without the use of downstream flanges.
         5) Valves shall be bubble-tight with rated pressure applied from either side and shall be tested with pressure applied in both directions.
         6) Provide epoxy lining and coating in compliance with AWWA C550.
         7) Valve shall be suitable for permitting entry of the tapping machine cutter.
      g. End Connections: Tapping valve shall have an ANSI B16.1, class 125 flange on one end for bolting to the tapping sleeve and a mechanical joint

type end connection on the slotted standard flange or other adapters for connection to the tapping machine.

h. Operator: As specified in the Valve Schedule

i. Testing: Tapping sleeve together with the tapping valve shall be tested at 350 psi for visible leakage before main is tapped.

j. Manufacturers: Provide products of one of the following:
   1) M&H Valve Company
   2) Clow Valve Company.
   3) Or equal.

2. Type 1110 – Mechanical Joint Tapping Sleeve.
   a. Standards: Outlet flange dimensions and drilling to comply with ANSI B16.1, class 125 and with MSS SP-60
   b. Working pressure: 200 psig
   c. Construction:
      1) Body: Iron Body
   d. Required Features:
      1) Sleeve to include ¾" NPT test plug
      2) Sleeve shall be in full compliance with NSF 61. Provide NSF 61 certificate for each sleeve.
      3) Sleeve shall be suitable for permitting entry of the tapping machine cutter.
   e. End Connections: ANSI B16.1, class 125 outlet flange
   f. Testing: Tapping sleeve together with the tapping valve shall be tested at 350 psi for visible leakage before main is tapped.
   g. Ordering: Prior to ordering the tapping sleeve the CONTRACTOR shall dig a test pit, verify the outside dimension and class of the existing pipe, and confirm with the manufacturer that the sleeve ordered will not leak while operating under the normal operating pressure of 200 psig.
   h. Manufacturers: Provide products of one of the following:
      1) U.S. Pipe
      2) Or equal.

N. Quick Connect:
   1. General:
      a. All coupling assemblies shall have a minimum pressure and temperature rating of 300 psi and 225 degrees F.
      b. Provide finger rings for all sizes 1-1/2 inch and above.
      c. Size and Location: As shown on the Drawings and as specified.
      d. Provide increaser or reducer fittings with connection is required for dissimilar size.
   2. Adaptor with Male NPT:
      a. Construction: Stainless steel.
      b. Manufacturer and Model No.:

1) Dover Corp. OPW Division, 633-F.
2) Or equal.

3. Adaptor with Female NPT:
   a. Construction: Stainless steel.
   b. Manufacturer and Model No.:
      1) Dover Corp. OPW Division, 633-A.
      2) Or equal.
4. Adaptor with Hose Shank:
   a. Construction: Stainless steel.
   b. Manufacturer and Model No.:
      1) Dover Corp. OPW Division, 633-E.
      2) Or equal.
5. Coupler with Male NPT:
   a. Construction: Stainless steel.
   b. Gasket: Buna-N.
   c. Manufacturer and Model No.:
      1) Dover Corp. OPW Division, 633-B.
      2) Or equal.
6. Coupler with Hose Shank:
   a. Construction: Stainless steel.
   b. Gasket: Buna-N.
   c. Manufacturer and Model No.:
      1) Dover Corp. OPW Division, 633-C.
      2) Or equal.
7. Coupler with Female NPT:
   a. Construction: Stainless Steel.
   b. Gasket: Buna-N.
   c. Manufacturer and Model No.:
      1) Dover Corp. OPW Division, 633-D.
      2) Or equal.
8. Coupler Plug:
   a. Construction: Stainless steel.
   b. Manufacturer and Model No.:
      1) Dover Corp. OPW Division, 634-A.
      2) Or equal.
9. Adaptor Cap:
   a. Construction: Stainless steel.
   b. Manufacturer and Model No.:
      1) Dover Corp. OPW Division, 634-B.
      2) Or equal.

O. Solenoid Valves:
   1. Type A – 2-Way Pilot Operated Slow-Closing Solenoid Valves:
      a. Construction:
         1) Body: Brass.

2) Disc: Buna-N.
3) Internal parts in contact with process fluid: Type 300 or 400 stainless steel.

b. Required Features:
1) Maintained manual operators, manual return type, unless otherwise specified in the Valve Schedule.
2) Fluid Controls Institute (FCI) Classification:
a) 3/8 to 3/4-inch sizes: FCI-82-1 Class CC.
b) 1 to 2-1/2-inch sizes: FCI-82-1 Class BB.

c. Operation: Normally closed (valve closed when de-energized, open when energized), unless otherwise specified in the Valve Schedule.

d. Electrical Rating: 120 VAC, 60-Hz, single phase, unless otherwise specified in the Valve Schedule.

e. Manufacturer and Model:
1) Automatic Switch Company (ASCO) Red-Hat II Model Number 8221G.
2) Or equal.

P. Strainers:
1. Type A – Bronze Body Y-Pattern Strainers:
a. Style: Y-Pattern with removable strainer screen.
b. Construction:
1) Body: Cast bronze.
2) Screen: 20 mesh Type 316 stainless steel, unless otherwise specified in the Valve Schedule.
c. Pressure Rating: 400 psi water service at 150 degrees F.
d. End Connections: Threaded.
e. Required Features:
1) Blowoff plug: NPT connection.
f. Manufacturer and Model:
1) Mueller Steam Specialties, Model No. 352.
2) Or equal.

Q. Hoses:
1. Style: Double braided synthetic flexible hose for maintenance and vessel area wash downs.
2. Threads: 3/4-inch as scheduled below NST.
3. Hose Size: 3/4-inch as schedule below.
4. Provide the following hoses:
a. 3/4 inch with quick connect coupling to attach to hose bib: Five – 100 foot long hoses.

2.2 ELECTRIC ACTUATORS (OPEN/CLOSE)

A. Manufacturers: Provide products of the following:

1. AUMA

B. Application Criteria:
   1. Ambient Temperature Rating: -20 to +158 degrees F.
   2. Ambient Humidity: 100 percent.
   3. Maximum Differential Pressures Across Closed Valves: Refer to Schedule of Valves with Electric Actuators at the end of this Section.
   4. Maximum Flows Through Full-Open Valves: Refer to Schedule of Valves with Electric Actuators located at end of this Section.
   5. Power Supply: 480-volt, three-phase, 60 Hertz.
   6. Control Voltage: 120 VAC, single phase, 60 Hertz.
   7. Torques: As determined by valve manufacturer.
   8. Duty Cycle: Sixty starts per hour, minimum.

C. General:
   1. Conform to AWWA C540 and this Section.
   2. Provide actuator operable with handwheel or chainwheel, even after disengaging and removing electric motor.
   3. Coordinate sizing of each electric actuator with valve manufacturer, who shall furnish valve and associated electric actuator and appurtenances as a unit.
   4. Electric actuators shall be suitable for valve orientation as shown.

D. Electric Motor:
   1. General:
      a. Provide motors suitable for "open/close" service, with high torque characteristics and minimum 70 degree C temperature rating.
   2. Motor Construction:
      a. Enclosure: NEMA 4X.
      b. Insulation: Class F.
      c. Service Factor: 1.15.
      d. Power Supply: 480VAC, 3-pase.
      e. Motor Size: horsepower as required.
      f. Provide winding thermostats for overcurrent protection.
      g. Efficiency: High-efficiency conforming to NEMA MG 1.
      h. Bearings: Anti-friction with minimum B-10 life of 100,000 hours, lifetime pre-lubricated and sealed.

E. Actuator Gearing:
   1. Housing: Die-cast aluminum or cast-iron.
   2. Close-coupled to electric motor.
   3. Input Shaft Gearing: Spur or bevel gear assembly.
   4. Output Shaft Gearing: Self-locking worm gears with minimum gear backlash to prevent valve disc chatter or vibration.
   5. Gearing shall be of hardened alloy steel or combination of hardened alloy steel and alloy bronze, accurately cut by hobbing machine.

6. Lubrication: Grease or oil bath.
7. Bearings: Ball or roller with minimum B-10 life of 100,000 hours, lifetime pre-lubricated and sealed.
8. Input Shaft: Hardened alloy steel.
9. Provide mechanical stops adjustable to plus-or-minus five degrees at each end of travel.

F. Limit Switches:
1. Provide each actuator with "end of travel" limit switches to allow control of desired end position for each direction of travel.
2. Provide open and close limit switches geared to drive mechanism and in step at all times, whether unit is operated electrically or manually, and whether or not actuator is powered by electric power supply. Friction devices or set-screw arrangements shall not be used to maintain the setting.
3. Limit switch gearing shall be appropriately lubricated.
4. Provide driven mechanism totally enclosed to prevent entrance of foreign matter and loss of lubricant.
5. Provide each limit switch with four auxiliary contacts. Two contacts shall close and two contacts shall open at a desired end position for each direction of travel.
6. Switches shall be rated five amperes at 120 volts.

G. Torque Switches:
1. Provide adjustable torque switches with each valve actuator. Torque switches shall operate during complete valve cycle without using auxiliary relays, linkages, latches, or other devices.
2. Wire torque switches to de-energize valve actuator motor when excessive torque is developed during each direction of travel.
3. It shall be possible to select the torque switches to control open and close limit positions in each direction of valve travel.
4. Provide dry contacts (five-amp, 120 VAC) for remote high torque alarm.

H. Handwheel and Chainwheel Operation:
1. Provide actuator with handwheel (or chainwheel as required) for manual operation, so connected that operation by motor will not cause handwheel or chainwheel to rotate.
2. Should electric power be returned to motor while handwheel or chainwheel is in use, unit shall prevent transmission of motor torque to handwheel or chainwheel.
3. Handwheel or chainwheel shall require no more than 80-pound effort on rim for seating or unseating load, and no more than 60 pounds on running load.
4. Handwheel or chainwheel shall have an arrow and the word "OPEN" or "CLOSE" indicating required rotation. Handwheel or chainwheel shall operate in clockwise direction to close.

5. Provide stem covers for rising stem gate valves as specified in Article 2.23 of this Section.

I. Controls:
   1. Provide the following controls in separate compartment integral or remote, as shown on the Contreact Drawings, with actuator. In the case of remote actuators, supply appropriate cabling.
   2. Enclosure: NEMA 4X.
   3. Starter: Combination reversing magnetic starter with circuit breaker and disconnect switch.
   4. Control Power Transformer: Provide transformer to transform rated three-phase, 60 Hertz power to 120 volts, single-phase. Transformer shall be complete with grounded and fused secondary and dual primary fuses.
   5. Provide "LOCAL/OFF/REMOTE" selector switch. In "LOCAL" position actuator shall be operated by "OPEN/CLOSE/STOP" pushbuttons. In "OFF" position, actuator shall be disabled from local and remote operation. In "REMOTE" position, "open/close/stop" control from remote source shall be enabled.
   6. Provide "OPEN/CLOSE/STOP" pushbuttons with hold-to-run or momentary contact selection.
   7. Provide "OPEN/CLOSE/STOP" indicating lights and zero-to-100 percent position indication in liquid crystal display window.
   8. Provide thermal overload and single-phasing protection of motor.
   9. Provide set of dry contacts to remotely indicate that actuator is available for remote operation.
   10. Actuator circuit boards shall be rated for high temperature service, minimum 55 degrees C.
   11. Provide electrical interlocks as shown.
   12. Provide 120 VAC space heater to maintain internal housing temperature at 20 degrees C.

J. Communication: The Actuators shall have DeviceNet Communication capability in accordance with Section 13453, DeviceNet.

K. Testing:
   1. Test each actuator in manufacturer's shop in conformance with AWWA C540.

2.3 ELECTRIC ACTUATORS (MODULATING)

A. Manufacturers: Provide products of one of the following:
   1. AUMA

B. Application Criteria:
   1. Ambient Temperature Rating: -20 to +158 degrees F.
   2. Ambient Humidity: 100 percent.

3. Maximum Differential Pressures across Closed Valves: Refer to Schedule of Valves with Actuators located at the end of this Section.
4. Maximum Flows Through Full Open Valves: Refer to Schedule of Valves with Actuators located at the end of this Section.
5. Duty Cycle: Continuous (minimum 1,200 starts/stops per hour), unless otherwise specified.
6. Power Supply: 480 VAC, three-phase, 60 Hertz.
7. Control Voltage: 120 VAC, single-phase, 60 Hertz.
8. Torque: As recommended by valve manufacturer.
9. Accepts 4 to 20 mADC input to positioner.

C. General:
1. Conform to AWWA C540 and this Section.
2. Provide actuator operable with handwheel even after electric motor has been disengaged and removed.
3. Coordinate sizing of each electric actuator with valve manufacturer who shall furnish valve and electric actuator as a unit.
4. Electric actuators shall be suitable for valve orientation shown.

D. Electric Motor:
1. General:
   a. Provide motors suitable for modulating service, of high torque characteristics and minimum 70 degrees C temperature rating.
2. Motor Construction:
   a. Enclosure: NEMA 4X.
   b. Insulation: Class H.
   c. Service Factor: 1.15.
   d. Power Supply: 480VAC, three phase, 60Hz.
   e. Motor Size: horsepower as required
   f. Provide winding thermostats for overcurrent protection.
   g. Efficiency: High-efficiency conforming to NEMA MG 1.
   h. Bearings: Anti-friction, B-10 life of 100,000 hours, lifetime pre-lubri-cated and sealed.

E. Actuator Gearing:
1. Housing: Die-cast aluminum.
2. Close-coupled to electric motor.
3. Input Shaft Gearing: Spur or bevel gear assembly.
4. Output Shaft Gearing: Self-locking worm gears with minimum gear backlash to prevent valve disc chatter or vibration.
5. Gearing shall be of hardened alloy steel or combination of hardened alloy steel and alloy bronze, accurately cut by hobbing machine.
6. Lubrication: Grease or oil bath.
7. Bearings: Ball or roller with minimum B-10 life of 100,000 hours, lifetime pre-lubricated and sealed.

8. Input Shaft: Hardened alloy steel.
9. Provide mechanical stops adjustable to plus-or-minus five degrees at each end of travel.
10. Provide mechanical position indication.

F. Limit Switches:
1. Provide each actuator with "END OF TRAVEL" limit switches to allow control of desired end position for each direction of travel.
2. Provide "OPEN" and "CLOSE" limit switches geared to drive mechanism and in step at all times, whether unit is operated electrically or manually and whether or not actuator is electrically powered. Friction devices or set-screw arrangements shall not be used to maintain setting.
3. Limit switch gearing shall be appropriately lubricated.
4. Provide drive mechanism totally enclosed to prevent entrance of foreign matter or loss of lubricant.
5. Provide each limit switch with four auxiliary contacts. Two contacts shall close and two contacts shall open at desired end position for each direction of travel.
6. Switches shall be rated five amperes at 120 VAC.

G. Torque Switches:
1. Provide adjustable double-torque switches with valve actuator.
2. Torque switches shall operate during complete valve cycle without using auxiliary relays, linkages, latches, or other devices.
3. Wire torque switches to de-energize valve actuator motor when excessive torque is developed during each direction of travel.
4. It shall be possible to select torque switches to control open and close limit positions in each direction of valve travel.
5. Provide dry contacts (five-amp, 120 VAC) for remote high torque alarm for automatically controlled valves.

H. Handwheel and Chainwheel Operation:
1. Equip actuator with andwheel or chainwheel for manual operation, so connected that operation by motor will not cause handwheel or chainwheel to rotate.
2. Should power be returned to motor while handwheel or chainwheel is in use, unit shall prevent transmission of motor torque to handwheel or chainwheel.
3. Handwheel or chainwheel shall require no more than 80-pound effort on rim for seating or unseating load, and no more than 60-pound effort on running load.
4. Handwheel or chainwheel shall have an arrow and word "OPEN" or "CLOSE" indicating required rotation. Handwheel or chainwheel shall operate in clockwise direction to close.
5. Handwheels and chain operators shall be as specified in Article 2.23 of this Section.

I. Controls:

1. Provide following controls in a separate compartment integral, or remote, as Shown on the Drawings, with the actuator. In the case of remote, supply appropriate cabling.
2. Enclosure: NEMA 4X.
3. Starter: Combination reversing magnetic starter with circuit breaker and disconnect switch.
4. Control Power Transformer: Provide transformer to transform rated three-phase, 60 Hertz power to 120 volts, single-phase. Transformer shall be complete with grounded and fused secondary and dual primary fuses.
5. Provide "LOCAL/OFF/REMOTE" selector switch. In "LOCAL" position actuator shall be operated by "OPEN/CLOSE/STOP" pushbuttons. In "OFF" position, actuator shall be disabled from local and remote operation. In "REMOTE" position, "open/close/stop" control from remote source shall be enabled.
6. Provide "OPEN/CLOSE/STOP" pushbuttons with hold-to-run or momentary contact selection.
7. Provide "OPEN/CLOSE/STOP" indicating lights and zero-to-100 percent position indication in liquid crystal display window.
8. Motor shall be de-energized when valve is jammed.
9. Provide thermal overload and single phasing protection of motor.
10. For monitoring of actuator, provide set of single-pole/double-throw (SPDT) dry contacts. Monitor relay shall indicate that actuator is available for remote operation.
11. Provide each actuator with position controller. Controller shall have the following features:
    a. Receive 4 to 20 mADC analog control signal and position valve in proportion to this signal.
    b. Adjustments for duty cycle, band width, span, and zero.
    c. On loss of control signal valve shall stay in its last position.
    d. Provision for adequate cooling of actuator.
12. Provide actuator with position transmitter capable of producing 4 to 20 mADC output signal. Transmitter shall be standard slidewire (potentiometer) position transducer providing an output corresponding to zero-to-100 percent of travel. Accuracy shall be plus-or-minus one percent of scale. Transmitter shall include integral temperature-compensated, constant-voltage source for slidewire excitation. Transmitter shall be integral to actuator.
13. Supply actuator with circuit boards for high temperature service, minimum 55 degrees C.
14. Provide 120 VAC space heaters to maintain internal housing temperature at 20 degrees C.

J. Communication: actuators shall have DeviceNet Communication capability in accordance with Section13453, DeviceNet.

K. Testing:

1. Test each actuator in manufacturer's shop in conformance with AWWA C540.

2.4 APPURTENANCES FOR EXPOSED METALLIC VALVES

A. General:
   1. For valves located less than five feet above operating floor, provide levers on four-inch diameter quarter-turn valves, and provide handwheels on all other valves, unless otherwise shown or specified.
   2. For valves located five feet or more above operating floor, provide chain operators.
   3. Where indicated, provide extension stems and floorstands.

B. Handwheels:
   1. Conform to applicable AWWA standards.
   2. Material of Construction: Ductile iron, or cast aluminum.
   3. Arrow indicating direction of opening and word "OPEN" shall be cast on trim of handwheel.
   4. Maximum Handwheel Diameter: 2.5 feet.

C. Chain Operators:
   1. Chains shall extend to three feet above operating floor.
   2. Provide 1/2-inch stainless steel hook bolt to keep chain out of walking area.
   3. Materials of Construction:
      a. Chain: Type 316L stainless steel.
      b. Chainwheel: Recessed groove type made out of Type 316 stainless steel.
      c. Guards and Guides: Type 316L stainless steel.
   4. Chain Construction:
      a. Chain shall be of welded link type with smooth finish. Chain that is crimped or has links with exposed ends is unacceptable.
   5. Provide geared operators where required to position chainwheels in vertical position.

D. Crank Operator:
   1. Crank operator shall be removable and fitted with rotating handle.
   2. Maximum Radius of Crank: 15 inches.
   3. Materials:
      a. Crank: Cast-iron or ductile iron.
      b. Handle: Type 304 stainless steel.
      c. Hardware: Type 304 stainless steel.

E. Extension Stems and Floor Stands for Gate Valves:
   1. Conform to the applicable requirements of AWWA C501 for sizing of complete lifting mechanism.
   2. Bench and Pedestal Floor Stands:

a. For valves requiring extension stems, provide bench or pedestal floor stands with handwheel or crank as indicated. Provide provisions for using portable electric actuator for opening and closing of valves.
b. Type: Heavy-duty with tapered roller bearings enclosed in a weatherproof housing, provided with positive mechanical seals around lift nut and pinion shaft to prevent loss of lubrication and to prevent moisture from entering housing. Provide lubrication fitting for grease. For valves conveying water that is potable or that will be treated to become potable, grease shall be food-grade and ANSI/NSF 61-listed. Base shall be machined.
c. Materials of Construction:
1) Housing: Cast-iron, ASTM A126, Class B.
2) Lift Nut: Cast bronze, ASTM B98/B98M.
3) Grease Fitting: Stainless steel.
4) Bolting: Type 316 stainless steel.

3. Wall brackets for floor stands shall be Type 316L stainless steel construction.
4. Extension Stems:
a. Materials of Stems and Stem Couplings: Type 316 stainless steel.
b. Maximum Slenderness Ratio (L/R): 100.
c. Minimum Diameter: 1.5-inch.
d. Threads: Acme.
e. Provide stem couplings where stems are furnished in more than one piece. Couplings shall be threaded and keyed or threaded and bolted and shall be of greater strength than the stem.
f. Weld to bottom of extension stem a Type 316 stainless steel cap suitable for square end of valve stem.
5. Bottom Couplings: Ductile iron with Type 316 stainless steel pin and set screw.
6. Stem Guides:
a. Material: Type 316 cast stainless steel with bronze bushing for stem. For submerged service, Type 316 cast stainless steel with stainless steel bushing for stem.
b. Maximum Stem Length Between Guides: Seven feet.
c. Stem guides shall be adjustable in two directions.
7. Furnish stem cover of clear butyrate plastic or Grade 153 Lexan with cast adapter for mounting cover to bench and floor stands. Provide stem cover with gasketing and breathers to eliminate water intrusion into operator and condensation within cover. Provide stem cover with mylar tape with legible markings showing valve position at one-inch intervals and open and close limits of valve.

F. Floor Boxes: Provide cast-iron floor boxes for valves that are to be operated from floor above valve. Boxes shall be equal in depth to floor slab. Boxes shall have cast-iron covers and be fitted with bronze bushing.

2.5 APPURTENANCES FOR BURIED METALLIC VALVES

A. Wrench Nuts:
   1. Provide wrench nuts on buried valves of nominal two-inch size, in accordance with AWWA C500.
   2. Arrow indicating direction of opening the valve shall be cast on the nut along with the word “OPEN”.
   3. Material: Ductile iron or cast-iron.
   4. Secure nut to stem by mechanical means.

B. Extension Stems for Non-Rising Stem Gate Valves and Quarter-turn Buried Valves:
   1. Provide extension stems to bring operating nut to six inches below valve box cover.
   2. Materials of Stems and Stem Couplings: Type 316 stainless steel.
   3. Maximum Slenderness Ratio (L/R): 100
   4. Provide top nut and bottom coupling of ductile iron or cast-iron with pins and set screws of Type 316 stainless steel.

C. Valve Boxes:
   1. Valve boxes shall be as indicated and as required.
   2. Type: Heavy-duty, suitable for highway loading, two-piece telescopic, and adjustable. Lower section shall enclose valve operating nut and stuffing box and rest on valve bonnet.
   3. Material: Cast-iron or ductile iron.
   4. Coating: Two coats of asphalt varnish conforming to FS TT-C-494.
   5. Marking: As required for service.

2.6 ANCHORAGES AND MOUNTING HARDWARE

A. General:
   1. Conform to Section 05051, Anchor Bolts, Toggle Bolts, and Concrete Inserts, except as modified in this Section.
   2. Obtain bolts, nuts, and washers for connection of valve and appurtenances to concrete structure or other structural members from valve Supplier.
   3. Bolts, nuts, and washers shall be of ample size and strength for purpose intended. Anchorages in concrete shall be at least 5/8-inch diameter.
   4. Provide stem guide anchorages of required strength to prevent twisting and sagging of guides under load.
   5. Materials: Provide bolts and washers of Type 316 stainless steel and nitrided nuts. Bolts shall have rolled threads. Bolts and nuts shall be electropolished to remove burrs.

2.7 TOOLS, LUBRICANTS, AND SPARE PARTS

A. Provide the following T-handle operating wrenches for buried valves:
   1. Length of T-Handle Operating Wrench: five feet.
   2. Quantity: two

B. Lubricants: For valves, actuators, and appurtenances requiring lubricants, provide suitable lubricants for initial operation and for first year of use following Substantial Completion. Lubricants for equipment associated with conveying potable water or water that will be treated to become potable shall be food-grade and ANSI/NSF 61-listed.

C. Tools, spare parts, and maintenance materials shall conform with Section 01783, Spare Parts and Maintenance Materials.

2.8 PAINTING OF EXPOSED VALVES, HYDRANTS, AND APPURTENANCES

A. Exterior steel, cast-iron, and ductile iron surfaces, except machined surfaces of exposed valves and appurtenances, shall be finish painted in manufacturer's shop. Surface preparation, priming, finish painting, and field touch-up painting shall conform to Section 09900, Painting.

2.9 PAINTING OF BURIED VALVES

A. Exterior steel, cast-iron, and ductile iron surfaces, except machined or bearing surfaces of buried valves, shall be painted in valve manufacturer's shop with two coats of asphalt varnish conforming to FS TT-C 494.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine conditions under which materials and equipment are to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:
   1. Install valves and appurtenances in accordance with:
      a. Supplier's instructions and the Contract Documents.
      b. Requirements of applicable AWWA standards.
      c. Applicable requirements of Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
   2. Install valves plumb and level. Install all valves to be free from distortion and strain caused by misaligned piping, equipment, and other causes.
   3. Position swing check valves and butterfly valves so that, when valve is fully open, valve disc does not conflict with piping system elements upstream and downstream of valve.

B. Exposed Valves:
   1. Provide supports for large or heavy valves and appurtenances as shown or required to prevent strain on adjoining piping.
   2. Operators:
      a. Install valves so that operating handwheels or levers can be conveniently turned from operating floor without interfering with access to other valves, piping, structure, and equipment, and as approved by ENGINEER.
      b. Avoid placing operators at angles to floors or walls.
      c. Orient chain operators out of way of walking areas.
      d. Install valves so that indicator arrows are visible from floor level.
      e. For motor-operated valves located lower than five feet above operating floor, orient motor actuator to allow convenient access to pushbuttons and handwheel.
   3. Floor Stands and Stems:
      a. Install floor stands as shown and as recommended by manufacturer.
      b. Provide lateral restraints for extension bonnets and extension stems as shown and as recommended by manufacturer.
      c. Provide sleeves where operating stems pass through floor. Extend sleeves two inches above floor.

C. Buried Valves:
   1. Install valve boxes plumb and centered, with soil carefully tamped to a lateral distance of four feet on all sides of box, or to undisturbed trench face if less than four feet.
   2. Provide flexible coupling next to each buried valve.

D. Plug Valves:
   1. Install plug valves that are in horizontal liquid piping with stem horizontal and plugs on top when valve is open. Plug shall be on upstream end when valve is closed.
   2. Install plug valves that are in vertical liquid piping with plug at top when closed or as recommended by valve Supplier.
   3. Supplier shall tag or mark plug valves to indicate proper mounting position.

3.3 FIELD QUALITY CONTROL

A. Field Tests:
   1. Adjust all parts and components as required to provide correct operation of valves.
   2. Conduct functional field test on each valve in presence of ENGINEER to demonstrate that each valve operates correctly.
   3. Verify satisfactory operation and controls of motor operated valves.
   4. Demonstrate satisfactory opening and closing of valves at specified criteria requiring not more than 40 pounds effort on manual actuators.

5. Test ten percent of valves of each type by applying 200 pounds effort on manual operators. There shall be no damage to gear actuator or valve.

B. Supplier's Services:
   1. Provide services of qualified factory-trained service technicians to check and approve installation of the following types of valves:
      a. Automatic Pressure Reducing Valves
   2. Supplier's serviceman shall perform the following:
      a. Instruct CONTRACTOR in installing equipment.
      b. Supervise installation of equipment.
      c. Inspect and adjust equipment after installation and ensure proper operation.
      d. Instruct OWNER's personnel in operating and maintaining the equipment.
   3. Manufacturer's representative shall make a minimum of two visits, with a minimum of eight hours onsite for each visit. First visit shall be for unloading supervision (if specified) and instruction of CONTRACTOR in installing equipment; second visit shall be for assistance in installing equipment; third visit shall be for checking completed installation and start-up of system; fourth visit shall be to instruct operations and maintenance personnel. Representative shall revisit the Site as often as necessary until installation is acceptable.
   4. Training: Furnish services of Supplier's qualified factory trained specialists to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of equipment. Training requirements, duration of instruction and qualifications shall be in accordance with Section 01821, Instruction of Operations and Maintenance Personnel.
   5. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

3.4 SUPPLEMENTS

A. The supplements listed below, following "End of Section" designation, are a part of this Specification Section:
   1. Table 15100-A, Valve Schedule.
      a. Valves 4 inches and larger in diameter are included in the Valve Schedule. For valves less than 4 inches in diameter, information is given in the specifications and on the Contract Drawings.
      b. The Valve Schedule is provided for the CONTRACTOR's convenience and does not relieve the CONTRACTOR from his responsibility to provide all valves and appurtenances as shown on the drawings and specifications.
      c. Valve Designation
         1) AAA-BBB-CCC
            a) AAA = Process Piping Abbreviation
            b) BBB = Valve Type
            c) CCC = Sequential Numeric Indicator

+ + END OF SECTION + +

TABLE 15100-A, VALVE SCHEDULE[1]

Valve Type Code	Valve Type No.	Quantity	Size (inches)	Max. Oper. Flow (gpm)	Operator	End Connection	Remarks
BWW/VTW-BFV-1N Through BWW/VTW-BFV-7N	See Section - 11900 GAC Pressure Vessel	7	8	1500	EOC	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Remote open/close.
BWW/VTW-BFV-1S Through BWW/VTW-BFV-7S	See Section - 11900 GAC Pressure Vessel	7	8	700	EOC	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Remote open/close.
GS-BFV-1N Through GS-BFV-7N	See Section - 11900 GAC Pressure Vessel	7	8	700	EOC	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Remote open/close.
GS-BFV-1S Through GS-BFV-7S	See Section - 11900 GAC Pressure Vessel	7	8	700	EOC	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Remote open/close.
GAC-BFV-1N Through GAC-BFV-7N	See Section - 11900 GAC Pressure Vessel	7	8	700	EOC	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Integral open/close.
GAC-BFV-1S Through GAC-BFV-7S	See Section - 11900 GAC Pressure Vessel	7	8	700	EOC	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Integral open/close.
GTW-BFV-1N Through GTW-BFV-7N	See Section - 11900 GAC Pressure Vessel	7	8	700	EM	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Integral modulating.

Valve Type Code	Valve Type No.	Quantity	Size (inches)	Max. Oper. Flow (gpm)	Operator	End Connection	Remarks
GTW-BFV-1S Through GTW-BFV-7S	See Section - 11900 GAC Pressure Vessel	7	8	700	EM	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Integral modulating.
BWS-BFV-1N Through BWS-BFV-7N	See Section - 11900 GAC Pressure Vessel	7	8	1,500	EOC	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Integral open/close.
BWS-BFV-1S Through BWS-BFV-7S	See Section - 11900 GAC Pressure Vessel	7	8	1,500	EOC	Flg	Valve and actuator provided by GAC pressure vessel system manufacturer. Integral open/close.
GPB-BFV-1	300	1	24	8,333	M	Flg	
GS-BFV-4	300	1	24	8,333	M	Flg	
GTW-BFV-1	300	1	24	8,333	M	Flg	
GUTW-BFV-1A Through GTW-BFV-1B	300	2	24	8,333	EM	Flg	Relocated from existing Filter Building Pipe Gallery as shown on D-08-102.
GUTW-BFV-2A Through GUTW-BFV-2B	300	2	24	8,333	EM	Flg	Contractor to provide new valves for UV Reactor 2.
PBWS-BFV-1	300	1	10	1,500	M	Flg	
PBWS-CV-1	400	1	10	1,500	-	Flg	
PBWS-BFV-2	300	1	10	1,500	M	Flg	
PBWS-BFV-3	300	1	10	1,500	EM	Flg	
SBWS-GA-1	1100	1	12	1,500	M	Flg/RMJ	Tapping Sleeve and Valve shall be rated for 250 psi operating pressure and tested at 350 psi
SBWS-BFV-1 Through SBWS-BFV-2	300	2	10	1,500	M	Flg	

Valve Type Code	Valve Type No.	Quantity	Size (inches)	Max. Oper. Flow (gpm)	Operator	End Connection	Remarks
SBWS-BFV-3	300	1	10	1,500	EM	Flg	Remote modulating.
SBWS-PRV-1	1000	1	10	1,500	-	Flg	See sizing schedule, Specification 15100, Section 2.1.O.
SBWS-PRV-2	1000	1	10	1,500	-	Flg	See sizing schedule, Specification 15100, Section 2.1.O.
PA-BV-1 Through PA-BV-4	See Section - 15483 Compressed Air System	4	1	-	M	Flg	
PA-PRV-1	See Section - 15483 Compressed Air System	1	2	-	M	Flg	Set to 50 psi. See specification 15483 for range.
PA-PRV-2 Through PA-PRV-5	See Section - 15483 Compressed Air System	4	1	-	M	Flg	Set to 30 psi. See specification 15483 for range.
GEQR-CV-1E	400	1	4	300	-	Flg	
GEQR-CV-1W	400	1	4	300	-	Flg	
GEQR-PV-1E	100	1	4	300	M	Flg	
GEQR-PV-1W	100	1	4	300	M	Flg	
RW-BFV-1 Through RW-BFV-3	300	2	24	8,333	H	RMJ	
GPSS-BFV-1	300	1	24	8,333	EOC	Flg	
FW-BFV-1	300	1	24	8,333	-	Flg	
GS-CV-1 Through GS-CV-3	400	3	14	5,500	-	Flg	
GS-BFV-1 Through	300	3	14	5,500	H	Flg	

Valve Type Code	Valve Type No.	Quantity	Size (inches)	Max. Oper. Flow (gpm)	Operator	End Connection	Remarks
GS-BFV-3							
FTWR-BV-1	210	1	12	833	EM	Flg	
GPSOF-FV-1	500	1	24	8,333	-	Flg	
RD-MV-1 Through RD-MV-4	600	4	6		M	Flg	
SR-PV-1	100	1	6		M	Flg	
SR-PV-2 Through SR-PV-5	100	4	8		M	Flg	
RD-PV-1	100	1	6		M	Flg	
RM-CV-1 Through RM-CV-2	400	2	8			Flg	
RM-PV-1 Through RM-PV-3	100	3	6		M	Flg	
BD-MV-1	600	1	6		M	Flg	
BD-PV-1 Through BD-PV-4	100	4	6		M	Flg	
BD-PV-5 Through BD-PV-6	100	2	8		M	Flg	
D-BV-1	210	1	4		EM	RMJ	
RM-PV-4 Through RM-PV-5	110	2	6		M	RMJ	

Notes:

1. GAC pressure vessel GAC fill and drain line manual valves not included in schedule. Contractor shall coordinate with GAC pressure vessel system manufacturer and Specification 11900.

The following abbreviations are used in the Valve Schedule.

A. Service Abbreviations

Service	Abbrev.
Backwash	BW
Backwash Treatment Influent	BT
Basin Drain	BD
Drain	D
Filter Influent	FI
Filter to Waste Return	FTWR
GAC Backwash Supply	BWS
GAC Backwash Waste/Vessel-to-Waste	BWW/VTW
GAC Bypass	GBP
GAC EQ Basin Overflow	GEQOF
GAC EQ Basin Recycle	GEQR
GAC Feed Pump Station Overflow	GPSOF
GAC Feed Pump Station Supply	GPSS
GAC Supply	GS
GAC Treated Water	GTW
GAC/UV Treated Water	GUTW
Plant Air	PA
Primary Backwash Supply	PBWS
Plant Water (<4")	PW (<4")
Plant Water (>4")	PW (>4")
Potable Water	W
Preliminary Treatment Overflow	PTO
Recycle	R
Residuals Drain	RD
Residuals Main	RM
Raw Water	RW
Sample Line	SL

Sanitary Force Main	FM
Sanitary Sewer	S
Secondary GAC Backwash Supply	SBWS
Settled Residuals	SR
Sludge Drain	SD
Storm Sewer	SS
Sump Pump Discharge	SPD
Vent	V

B. Valve Type Abbreviations

Valve	Abbrev
Backflow Prevention Assemblies	BFP
Ball Valve	BV
Butterfly	BFV
Check Valve	CV
Flap Valve	FV
Gate Valve	GA
Mud Valve	MV
Plug Valve	PV
Pressure Reducing Valve	PRV
Telescopic Valves	TV

C. Operator Abbreviations

Operator	Abbrev
Electric Open/Close	EOC
Electric Modulating	EM
Hydraulic	H
Manual	M

D. End Connection Abbreviations

End Connection	Abbrev
Compressed Fitting	C
Flanged	Flg
Groved End	GE
Mechanical	MJ
Restrained Mech.	RMJ

++ END OF SECTION ++

SECTION 15103

AIR VALVES
USED FOR WATER AND WASTEWATER

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish, install, and test Air Valves for water and wastewater service complete with appurtenances.
   2. This Section does not include valves used for:
      a. Plumbing.
      b. Heating, ventilating, air conditioning, steam, or condensate systems.
      c. Instrumentation.
      d. Sprinkler systems.
      e. Chemical feed systems
      f. Sewage sludge, process sludge, and grit
   3. This Section does not include:
      a. Valves specified in other Sections
      b. Valves furnished with equipment
      c. Non-metallic valves.

B. Coordination:
   1. Review installation procedures for this and other Specification sections and coordinate Work that must be installed with or before Work under this Section.
   2. If this is a multiple-prime contract project, provide timely advance notification of schedule of work to other contractors who may need to install items at same time or before Work included in this Section.

C. Related Sections:
   1. Section 09910, Painting
   2. Section 15100, Valves and Appurtenances
   3. Section 15145, Domestic Water Piping Specialties

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ANSI/AWWA C512, Air Release, Air Vacuum and Combination Air Valves for Waterworks Service
   2. ANSI/AWWA C550, Protective Interior Coatings for Valves and Hydrants.
   3. ANSI/NSF 61 Drinking Water Components – Health Effects

1.3 DEFINITIONS

A. The following definitions apply to this Section.
   1. Air Release Valve: A hydromechanical device designed to automatically release to atmosphere small pockets of air as they accumulate in a pipeline when pipeline system is full and operating under pressure.
   2. Air/Vacuum Valve: Direct-acting, float-operated, hydromechanical device designed to automatically release or admit large volumes of air during filling or draining of a pipeline or piping system. Valve will open to relieve negative pressures and will not reopen to vent air when system is full and under pressure.
   3. Air Valve: Valve of one of the following types: Air Release Valve, Air/Vacuum Valve, or Combination Air Valve.
   4. Combination Air Valve: Device having features of an Air Release Valve and Air/Vacuum Valve.
   5. Maximum and Minimum Working Pressure: Pressure range at which valve is designed to function.
   6. Orifice: Opening in valve mechanism through which air is expelled from or admitted into pipeline or piping system.
   7. Valve Design Pressure: Maximum pressure to which a valve may be subjected without exceeding allowable stress of its components.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall be able to provide documentation of at least five installations of substantially similar equipment to that specified, in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Valves of the same type, including specified accessories, shall be products of or furnished by a single air valve manufacturer.

C. Regulatory Requirements.
   1. Drinking Water Requirements: Valves that will be in contact with potable water or water that will be treated to become potable shall comply with ANSI/NSF 61 and the Safe Drinking Water Act.

1.5 SUBMITTALS

A. Action Submittals.
   1. Shop Drawings: Submit the following for each type and size of valve specified:
      a. Product data sheet.
      b. Complete catalog information, including dimensions, weight, performance data, Orifice size, specifications, and identification of materials of each part.

B. Informational Submittals:

1. Certifications: Submit a certificate signed by manufacturer of each product stating that product conforms to applicable referenced standards and specified requirements.
2. Test Reports: Provide results of successful factory tests prior to shipping products to the Site.
3. Manufacturer's Reports: Submit written report of results of each visit to Site by a manufacturer's serviceman, including purpose and time of visit, tasks performed, and results obtained.

C. Closeout Submittals.
1. Operation and Maintenance Data:
a. Submit complete operation and maintenance manual for all Air Valves in the Contract, including maintenance data and schedules in sufficient detail for disassembly and assembly of valve, and identifying parts that can be replaced.
b. Furnish operation and maintenance manuals per Section 01781, Operation and Maintenance Data.
2. Spare Parts: Provide spare parts and list of recommended spare parts as specified in this Section:

1.6 DELIVERY, STORAGE, AND HANDING

A. Packing, Shipping, Handling, and Unloading:
1. Prepare valves for shipping per Section 6.2 of ANSI/AWWA C512.
2. Conform to Section 01651, Transportation and Handling of Products.

B. Acceptance at Site:
1. Inspect all boxes, crates, and packages upon delivery to Site and notify ENGINEER in writing of loss or damage to products. Promptly remedy loss and damage to new condition per manufacturer's instructions.

C. Storage and Protection:
1. Keep all products off ground using pallets, platforms, or other supports. Protect products from corrosion and deterioration.
2. Conform to Section 01661, Storage and Protection of Products.

1.7 MAINTENANCE

A. Extra Materials
1. Furnish complete valves or sets of field replaceable parts for each type and size of valve installed, tagged and boxed for long-term storage as follows:

Quantity of Valves Installed	Spare Valves [1] or Sets of Spare Parts [2]
1 to 5	1
6 to 10	2
11 to 15	3
16 or more	5

Notes:

(1) For valves smaller than 4-inch diameter furnish complete valve instead of sets of spare parts. Complete valve does not include accessories that are not typically furnished with valve model.

(2) Set of field-replaceable spare parts includes one gasket and all field-replaceable seats and bushings.

2. Provide list of manufacturer's recommended spare parts, based on the quantity of each size and type of valve provided, including current pricing and delivery time. Provide recommendations for the number of spare valves based on the same criteria, including pricing and delivery time.

PART 2 – PRODUCTS

2.1 GENERAL

A. Extent:
   1. Provide valves included in this Section, per the schedule included in this Section and as shown on the Drawings.

B. Requirements:
   1. Valve Design Pressure: Unless otherwise specified, Valve Design Pressure shall be equal to or exceed design pressure of pipe or equipment on which the valve is installed.
   2. Valve Type, Service, Inlet Size, Orifice Size, Accessories, and Required Features: Provide per the schedule in this Section.
   3. Materials: Air Valve materials shall be suitable for long-term use in the service specified.
   4. Ends:
      a. Provide per the schedule in this Section.
      b. Comply with valve connection requirements in Section 4.3 of ANSI/AWWA C512.
   5. Operating Pressure Range: Valves shall be suitable for pressure range specified in the schedule in this Section. Valve Design Pressure shall be greater than the valve's Maximum and Minimum Working Pressure.
   6. Air Valves in water service shall comply with ANSI/AWWA C512 unless otherwise shown or specified.
   7. Air Valves shall be suitable for operating pressures between 1 and 150 psi.

C. Markings:
   1. Mark valves per Section 6.1 of ANSI/AWWA C512.

D. Manufacturers and Model Numbers:
   1. Valve manufacturers and model numbers are in the schedule included in this Section.

2.2 AIR VALVES FOR WATER SERVICE

A. Air Release Valve, ½ Inch to 6 Inches:
   1. Suitable for potable water service
   2. As defined above.
   3. Air/water Inlet: See schedule.
   4. Air Outlet: NPT.
   5. Rated 150 psi working pressure, cast iron, ductile iron, or steel body, cover with stainless steel float and trim.
   6. Orifice diameter: ½ inch, unless drawings specifically call for different model and/or orifice size.
   7. Manufacturer and Model:
      a. APCO Willamette Valve and Primer Corp., Series 200.
      b. Val-Matic; Series 45.5.

B. Air and Vacuum Valve, ½ Inch to 6 Inches:
   1. Suitable for potable water service.
   2. As defined above.
   3. Air/water Inlet: See schedule..
   4. Air Outlet: NPT.
   5. Rated 150 psi working pressure, cast iron, ductile iron, or steel body, cover with stainless steel float and trim.
   6. Manufacturer and Model:
      a. APCO Willamette Valve and Primer Corp., Series 140 or 150.
      b. Val-Matic; Series 100.

C. Combination Air Valve, ½ Inch to 6 Inches
   1. Suitable for potable water service.
   2. As defined above.
   3. Single or dual body
   3. Air/water Inlet: See schedule..
   4. Air Outlet: NPT.
   5. Rated 150 psi working pressure, cast iron, ductile iron, or steel body, cover with stainless steel float and trim.
   6. Manufacturer and Model:
      a. APCO Willamette Valve and Primer Corp., Series 147C.
      b. Val-Matic; Series 202C.2..

2.3 ACCESSORIES

A. Isolating Valves:
   1. Provide isolating valves in the schedule included in this Section and as shown. Isolating valves shall conform to applicable requirements of Sections 15100, Valves and Appurtenances and Section 15145, Domestic Water Piping Specialties.
   2. Valve Design Pressure of isolating valve shall equal or exceed Valve Design Pressure of the connected Air Valve.
   3. All isolating valves shall be rated for a minimum pressure of 150 psi

B. Anti-Slam Devices:
   1. Provide anti-slam devices on inlet to air/vacuum valves and combination air valves where indicated.
   2. Pressure rating of anti-slam device shall equal or exceed Valve Design Pressure of connected Air Valve.
   3. Ends shall be as required for connecting to Air Valve.
   4. Anti-slam devices shall be as normally furnished by specified Air Valve manufacturers and be cast iron or ductile iron with bronze or stainless steel disc and trim.

C. Vacuum Check Valves:
   1. Provide vacuum check valves for Air Release Valves where indicated.
   2. Vacuum check valves shall be as normally furnished by Air Valve manufacturer.

D. Throttling Devices
   1. Provide throttling device on discharges of Air/Vacuum Valves where indicated.
   2. Throttling device shall have a field-adjustable Orifice and be as normally furnished by Air Valve manufacturer.

2.4 FACTORY PAINTING

A. Interior Surfaces
   1. Extent: Paint ferrous surfaces except stainless steel surfaces.
   2. Paint: Paint shall be as normally provided by Air Valve manufacturer for the specified application, except for potable water service valves which shall be coated with paint complying with ANSI/AWWA C550 and ANSI/NSF-61.

B. Exterior Surfaces
   1. Exterior surfaces of cast-iron, ductile iron, and steel other than stainless steel, except machined surfaces of valves and appurtenances, shall be finish painted.
   2. Surface preparation, painting, and field touch-up painting shall be per Section 09910, Painting.
   3. Furnish valve with only a prime coat if so indicated.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect Air Valves per Section 5 of ANSI/AWWA C512, except test pressure shall be increased from 150 percent of working pressure to 200 percent of working pressure. Do not ship valves that are not successfully tested.

PART 3- EXECUTION

3.1 INSPECTION

A. Examine conditions under which Work is to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of Work. Do not proceed with Work until unsatisfactory conditions have been corrected.

B. Examine valves and remove packing and foreign materials from interior of valve. Report defects to ENGINEER

3.2 INSTALLATION

A. Install valves and appurtenances as shown on the Drawings and per Air Valve manufacturer's recommendations, approved Shop Drawings, and applicable codes and standards.

B. Install valves plumb and vertical.

C. Install with an isolating valve. Remove isolating valve's operating handle or lever and deliver to OWNER.

D. Adjust throttling devices, if provided, for smooth, non-slam and waterhammer-free operation.

3.3 FIELD QUALITY CONTROL (NOT USED)

3.4 SCHEDULE

A. The schedules listed below, following the "End of Section" designation, are a part of this Specification section.
   1. Table 15103-A, Air Valve Schedule.
      a. The Air Valve Schedule is provided for the CONTRACTOR's convenience and does not relieve the CONTRACTOR from his responsibility to provide all valves and appurtenances as shown on the drawings and specifications.

+ + END OF SECTION + +

TABLE 15103- AIR VALVE SCHEDULE

No.	Valve Type	Inlet Dia. (inch)	Inlet Press. (psi)	Outlet Press. (psi)	Max. Oper. Flow (gpm)	Isolation Valve Type	Inlet Connection	Access-ories
GS-CA-1 Through GS-CA-3	CA	3	30	0	5,500	BA	Flg	---
GS-AR-1	AR	2	30	0	8,333	BA	NPT	---
GUTW-CA-1	CA	3	30	0	8,333	BA	NPT	---
GUTW-CA-2	CA	3	30	0	8,333	BA	NPT	---
GPSS-AR-1	AR	2	30	0	8,333	BA	NPT	---
RW-AR-1	AR	2	30	0	8,333	BA	NPT	---
RW-AR-2	AR	2	30	0	8,333	BA	NPT	---
FTWR-AR-1	AR	2	30	0	833	BA	NPT	---

Abbreviations that may be used in the Schedule:

Valve Type

Air Release Valve	AR
Air/Vacuum Valve	AV
Combination Air Valve	CA

Inlet Connection

Flanged	Flg
Threaded	NPT

Isolating Valve Type

Ball Valve	BA

Accessories

Vacuum Check	VC
Throttling Device	TD
Anti-slam Device	SV
Outlet Cowl or Hood	OC

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SECTION 15110

CHEMICAL FEED SYSTEM APPURTENANCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall furnish all labor, materials, equipment and incidentals required to install, test and start-up the chemical feed systems appurtenances as shown and specified.
   2. The extent of the Work is shown on the Drawings and specified herein.
   3. The chemical piping systems are defined to include:
      1. All piping carrying process chemicals and not otherwise specified; and associated valves and accessories.
      2. Chemical spillage piping not otherwise specified.

B. Related Sections:
   1. Division 11, Applicable Sections on Equipment.
   2. Division 13, Applicable Sections on Instrumentation and Controls.
   3. Division 15, Applicable Sections on Piping, Valves and Appurtenances.
   4. Division 16, Electrical.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American National Standards Institute, (ANSI).
   2. American Society for Testing and Materials, (ASTM).
   3. American Water Works Association, (AWWA).
   4. Hydraulics Institute, (HI).
   5. Institute of Electrical and Electronics Engineers, (IEEE).
   6. National Electrical Code, (NEC).
   7. National Electrical Manufacturers' Association, (NEMA).
   8. National Fire Protection Association, (NFPA).
   9. National Sanitation Foundation, (NSF).
   10. U.S. Department of Labor, Occupational Safety and Health Administration, (OSHA).
      1. Safety and Health Standards 29 CFR 1910.

1.3 SUBMITTALS

A. Shop Drawings and Product Data:
   1. Comply with Section 01332, Shop Drawing Procedures.

2. Manufacturer's Certification: Submit manufacturer's certification for all piping, valves, and accessories to indicate that materials used are suitable for chemical service intended.

B. Operation and Maintenance Data:
   1. Submit complete Installation, Operation and Maintenance Manuals, including, test reports, maintenance data and schedules, description of operation, and spare parts information in each chemical feed system manual.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

1.4 DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements of Section 01651, Transportation and Handling of Products, and Section 01661, Storage and Protection of Products.

B. Packing, Shipping, Handling and Unloading:
   1. Deliver materials to the Site to ensure uninterrupted progress of the Work.

C. Storage and Protection:
   1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.

D. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the Site. CONTRACTOR shall notify CCA, in writing, if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Thermoplastic Pipe: Polyvinyl Chloride (PVC) pipe, as shown and specified in Section 15067, Thermoplastic Pipe.

B. Chemical Feed Tubing:
   1. Provide hose barb x NPT end connections to transition between hose/tubing and hard pipe. Provide hose barb x hose barb connections between sections of hose/tubing. End connections shall be constructed of material suitable for the chemical being conveyed. Secure tubing/hose to each hose barb with a stainless steel pipe clamp.
   2. Manufacturer and Model: Nalgene 980 braided vinyl tubing.

2.2 VALVES

A. Anti-Siphon Valves:
   1. Relief setting adjustable from 5 psi to 100 psi.
   2. Maximum inlet pressure: 150 psi
   3. PVC body with PTFE diaphragm.
   4. Manufacturer and Model:
      a. Plast-O-Matic Series RVDT.
      b. Or equal.

B. Ball Valves:
   1. Type: Plastic True Union:
   2. Style: Standard ball with circular port.
   3. Construction:
      a. Body, ball, handle, stem, union nut, seal carrier, end connector: PVC.
      b. Seals, O-Rings: Viton, unless otherwise specified.
      c. Seats: PTFE.
   4. End Connection: Socket welded, unless otherwise specified.
   5. Pressure Rating: 150 psi at 70 degrees F.
   6. Operator: Lever unless otherwise specified or shown in the drawings.
   7. Manufacturer and Model:
      a. Hayward Industrial Products, True Union Ball Valve.
      b. Chemtrol, Tru-Bloc^{tm} True Union Ball Valve.
      c. Spears Manufacturing Company, True Union Ball Valve.
      d. Or equal.

C. Vented Ball Valves:
   1. Style: Standard ball with circular port conforming to AWWA C507 and hole drilled in one side to allow venting.
   2. Construction:
      a. Body, ball, handle, stem, union nut, seal carrier, end connector: PVC.
      b. Seals, O-Rings: Viton, unless otherwise specified.
      c. Seats: PTFE.
   3. End Connection: Socket welded, unless otherwise specified.
   4. Pressure Rating: 150 psi at 70 degrees F.
   5. Operator: Lever unless otherwise specified or shown in the drawings.
   6. Valve Installation: Install vented ball valve with vent hole directed upstream.
   7. Manufacturer and Model:
      a. Plast-O-Matic Valves, Inc., True Union Vented Ball Valve.
      b. NIBCO Inc. Chemtrol®, Tru-Bloc^{tm} True Union (Vented) Ball Valve.
      c. Or equal.

D. Butterfly Valves:
   1. Type: Plastic, Standard Body

2. Construction:
    a. Shafts: Titanium. Shafts shall be totally isolated from the conveyed media and have full engagement over the entire length of the disc.
    b. Disc and Body: PVC.
    c. Seats and O-rings: Viton.
3. End Connection: Flanged, conforming to ANSI B16.5, CL 150, unless otherwise specified.
4. Operator: Manual lever.
5. Class: Class 150.
6. Manufacturer: Provide butterfly valves of one of the following:
    a. Asahi/America.
    b. Or equal.

E. Check Valves:
1. Type: PVC ball check valve.
2. Construction: PVC with EPDM seals and seat.
3. Size: Same as connecting piping unless shown otherwise.
4. End corrections: Socket welded.
5. Manufacturer:
    a. Chemtrol.
    b. Asahi America.
    c. Or equal.

F. Pressure Relief Valves:
1. Type: PVC pressure relief valves.
2. Construction:
    a. Body: PVC.
    b. Bonnet: PVC.
    c. Seat: PVC.
    d. Piston: PVC.
3. End Connection: Flanged or threaded.
4. Pressure Rating: 100 psi at 70 degrees F.
5. Pressure Relief Setting: Factory set at 30 psi; field adjustable.
6. Manufacturer:
    a. Asahi/America (flanged).
    b. Hayward (threaded).
    c. Or equal.

2.3 CHEMICAL PIPING SUPPORTS

G. General:
1. Provide chemical feed piping supports as shown and specified.
2. Pipe support struts, rods, bolts and other appurtenances shall be suitable for the chemicals that are being conveyed.
3. Chemical feed pipe support struts, rods, bolts and other appurtenances shall be as identified in Section 15055 Pipe Hangers and Supports.

4. Run piping in groups where practicable and parallel to building wall generally. Provide minimum clearance of 1 inch between pipe and other work.
5. Install hangers or supports at all locations where pipe changes direction.
6. All hangers and supports shall be capable of adjustment after placement of piping.
7. Support vertical piping at each floor and between floors by stays or braces to prevent rattling and vibration.
8. Hanger rods shall be straight and vertical. Chain, wire, strap or perforated bar hangers shall not be used. Hangers shall not be suspended from piping.
9. Maximum support spacing unless otherwise shown or approved shall be as follows:

Pipe Size (in.)	Spacing (ft)
Up to 1-1/2	5
2 through 3	6
3-1/2 and greater	7

2.4 ACCESSORIES

H. General: Provide accessories as shown and specified.

I. Unions:
   1. Construction: Use same material as connecting piping with Viton O-Rings.
   2. Size: Same as connecting piping unless shown otherwise.
   3. End connections: Socket welded as shown and specified.
   4. Manufacturer:
      a. Chemtrol.
      b. R&G Sloane.
      c. Or equal.

2.5 VALVE IDENTIFICATION TAGS

J. Provide identification tags for all valves in accordance with the requirements of Section 10400, Identification Devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install piping and valves in accordance with the manufacturer's recommendations, the Contract Documents, and reviewed Shop Drawings.

B. Provide unions in lines near each piece of equipment and each valve where necessary for installation or disassembly.

C. Install tees with threaded plugs where piping changes directions to facilitate draining and cleaning of the line.

D. Comply with Section 15051 for Buried Piping Installation and Section 15052 for Exposed Piping Installation except where otherwise specified.

E. Sleeves:
   1. Furnish and install wall sleeves at each point where piping passes through walls or floors.

F. Install composite utility markers at changes in direction of chemical piping as directed by the ENGINEER.

3.2 TESTING

A. Perform hydrostatic pressure tests for chemical piping to test pressure listed in 15051 and 15052 piping schedules.

B. Notify ENGINEER 48 hours in advance of testing.

C. Inspect all valves, joints, and specialties for tightness and for proper operation while under test pressure.

D. Repair and retest all lines which fail to pass the specified tests.

E. The CONTRACTOR is responsible for all testing and shall pay all costs incurred during the specified testing.

+ + END OF SECTION + +

SECTION 15111

GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Brass ball valves.
   2. Bronze ball valves.
   3. Iron ball valves.
   4. Bronze lift check valves.
   5. Bronze swing check valves.
   6. Iron swing check valves.
   7. Iron swing check valves with closure control.

B. Related Sections:
   1. Division 2 water distribution piping Sections for general-duty and specialty valves for site construction piping.
   2. Division 15 plumbing piping Sections for specialty valves applicable to those Sections only.
   3. Division 15 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G/ SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set angle, gate, and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
   1. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller except plug valves.

E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
   1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

F. Valve-End Connections:
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Solder Joint: With sockets according to ASME B16.18.
   3. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. DynaQuip Controls.
      d. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
      e. Hammond Valve.
      f. Jamesbury; a subsidiary of Metso Automation.
      g. Jomar International, LTD.
      h. Kitz Corporation.
      i. Legend Valve.
      j. Marwin Valve; a division of Richards Industries.
      k. Milwaukee Valve Company.
      l/ NIBCO INC.
      m. Red-White Valve Corporation.
      n. RuB Inc.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig (1035 kPa).
      c. CWP Rating: 600 psig (4140 kPa).
      d. Body Design: Two piece.
      e. Body Material: Forged brass.
      f. Ends: Threaded.
      g. Seats: PTFE or TFE.
      h. Stem: Brass.
      i. Ball: Chrome-plated brass.
      j. Port: Full.

B. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
      d. Hammond Valve.
      e. Jamesbury; a subsidiary of Metso Automation.
      f. Kitz Corporation.
      g. Marwin Valve; a division of Richards Industries.
      h. Milwaukee Valve Company.
      i. RuB Inc.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig (1035 kPa).
      c. CWP Rating: 600 psig (4140 kPa).
      d. Body Design: Two piece.
      e. Body Material: Forged brass.
      f. Ends: Threaded.
      g. Seats: PTFE or TFE.
      h. Stem: Stainless steel.
      i. Ball: Stainless steel, vented.
      j. Port: Full.

2.3 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Conbraco Industries, Inc.; Apollo Valves.
      c. Crane Co.; Crane Valve Group; Crane Valves.
      d. Hammond Valve.
      e. Lance Valves; a division of Advanced Thermal Systems, Inc.
      f. Legend Valve.
      g. Milwaukee Valve Company.
      h. NIBCO INC.
      i. Red-White Valve Corporation.
      j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig (1035 kPa).
      c. CWP Rating: 600 psig (4140 kPa).
      d. Body Design: Two piece.
      e. Body Material: Bronze.
      f. Ends: Threaded.
      g. Seats: PTFE or TFE.

h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

B. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Lance Valves; a division of Advanced Thermal Systems, Inc.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.4 IRON BALL VALVES

A. Class 125, Iron Ball Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. American Valve, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Kitz Corporation.
d. Sure Flow Equipment Inc.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-72.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Split body.
d. Body Material: ASTM A 126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

2.5 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. Crane Co.; Crane Valve Group; Stockham Division.
   2. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Design: Vertical flow.
      d. Body Material: ASTM B 61 or ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: Bronze.

B. Class 125, Lift Check Valves with Nonmetallic Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flo Fab Inc.
      b. Hammond Valve.
      c. Kitz Corporation.
      d. Milwaukee Valve Company.
      e. Mueller Steam Specialty; a division of SPX Corporation.
      f. NIBCO INC.
      g. Red-White Valve Corporation.
      h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Design: Vertical flow.
      d. Body Material: ASTM B 61 or ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: NBR, PTFE, or TFE.

2.6 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Crane Co.; Crane Valve Group; Crane Valves.
      c. Crane Co.; Crane Valve Group; Jenkins Valves.
      d. Crane Co.; Crane Valve Group; Stockham Division.
      e. Hammond Valve.
      f. Kitz Corporation.
      g. Milwaukee Valve Company.

h. NIBCO INC.
i. Powell Valves.
j. Red-White Valve Corporation.
k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
l. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B 62, bronze.
   e. Ends: Threaded.
   f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Kitz Corporation.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Red-White Valve Corporation.
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B 62, bronze.
   e. Ends: Threaded.
   f. Disc: PTFE or TFE.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Kitz Corporation.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Red-White Valve Corporation.
   i. Zy-Tech Global Industries, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 3.

b. CWP Rating: 300 psig (2070 kPa).
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 300 psig (2070 kPa).
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: PTFE or TFE.

2.7 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Kitz Corporation.
f. Legend Valve.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Red-White Valve Corporation.
k. Sure Flow Equipment Inc.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
m. Zy-Tech Global Industries, Inc.
2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.

f. Trim: Bronze.
g. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Composition.
g. Seat Ring: Bronze.
h. Disc Holder: Bronze.
i. Disc: PTFE or TFE.
j. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 500 psig (3450 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.

2.8 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. NIBCO INC.
2. Description:
a. Standard: MSS SP-71, Type I.

b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed, exterior lever and spring.

B. Class 125, Iron Swing Check Valves with Lever- and Weight-Closure Control:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed, exterior lever and weight.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, brass or bronze with brass or bronze stainless-steel trim.
3. Bronze Swing Check Valves: Class 125, Class 150, bronze, nonmetallic disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves: Class 150.
3. Iron Swing Check Valves: Class 125, Class 250, metal, nonmetallic-to-metal seats.
4. Iron Swing Check Valves with Closure Control: Class 125, lever and spring.

+ + END OF SECTION + +

SECTION 15120

PIPING SPECIALTIES AND ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install all piping specialties and accessories.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before piping specialties and accessories Work.

C. Related Sections:
   1. Section 09910, Painting.
   2. Section 15051, Buried Piping Installation
   3. Section 15052, Exposed Piping Installation.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings.
   2. ANSI B16.39, Malleable Iron Threaded Pipe Unions.
   3. ASME B31, Standards of Pressure Piping.
   4. ASTM A53/A53M, Specification for Pipe, Steel, Black and Hot-dipped, Zinc-Coated, Welded and Seamless.
   5. ASTM A105/A105M, Specification for Carbon Steel Forgings and Piping Applications.
   6. ASTM B169/B169M Specification for Aluminum Bronze Sheet, Strip, and Rolled Bar.
   7. ASTM B650, Specification for Electro-Deposited Engineering Chromium Coatings of Ferrous Substrates.
   8. ASTM F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
   9. AWWA C606, Grooved and Shouldered Joints.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer shall have at least five years experience producing substantial similar products to those specified and shall be able to provide documentation of at least five installations in satisfactory operation for at least five years each.

B. Component Supply and Compatibility:
   1. Obtain each type of piping specialty and accessory product included in this Section, regardless of component manufacturer, from a single piping specialty and accessories manufacturer.
   2. Supplier shall prepare, or review, and approve all submittals for components furnished under this Section.
   3. Components shall be suitable for specified service conditions and be integrated into overall assembly by the Supplier.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings: Submit piping layout Shop Drawings in accordance with Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
   2. Product Data: Submit product data on each type of coupling, expansion joint, and other piping specialties and accessories, including gaskets, hardware, and appurtenances sufficient to demonstrate compliance with the Contract Documents.

B. Informational Submittals: Submit the following:
   1. Certificates: When requested by ENGINEER submit certificate attesting to compliance with standards referenced in this Section, signed by manufacturer.
   2. Manufacturer's Instructions: Provide instructions for handling, storing, installing, and adjusting of products.
   3. Source Quality Control: When requested by ENGINEER, submit results of source quality control tests.
   4. Qualifications Statements: Submit qualifications of manufacturer when requested by ENGINEER.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

PART 2 – PRODUCTS

2.1 COUPLINGS

A. Sleeve-type, Flexible Couplings:
   1. Pressure and Service: Same as connected piping.
   2. Products and Manufacturers: Provide products of one of the following:
      a. Style 38, as manufactured by Dresser Piping Specialties, part of Dresser, Inc.
      b. Style 411, by Smith Blair, Inc.
      c. Or equal.
   3. Material: Ductile Iron.
   4. Gaskets: Suitable for specified service, as recommended by manufacturer.
   5. Bolts and Nuts: Alloy steel, corrosion-resistant, primer-coated. For buried or submerged applications, provide stainless steel bolts complete with washers complying with ASTM F593, AISI Type 316 and with nitrided stainless nuts.
   6. Harnessing:
      a. Harness couplings to restrain pressure piping. For pipelines that will be under pressure, test pressures are specified in piping schedules in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
      b. Tie adjacent flanges with bolts of corrosion-resistant alloy steel. Provide flange-mounted stretcher bolt plates to be designed by manufacturer, unless otherwise approved. For buried or submerged applications, provide external bolting and other hardware of Type 316 stainless steel, including tie bolts, bolt plates, lugs, nuts, and washers.
      c. On plain-end piping, for harnessing couplings, provide anchor restraint system such as Dresser Piping Specialties STAR Anchor Style 443, or equal.
      d. Conform to dimensions, size, spacing, and materials for lugs, bolts, washers, and nuts as recommended by manufacturer and approved by ENGINEER for pipe size, wall thickness, and test pressure required. Provide minimum 5/8-inch diameter bolts.
   7. Remove pipe stop(s) if used, unless otherwise shown or specified.

B. Flanged Coupling Adapters:
   1. Description: One end of adapter shall be flanged and opposite end shall have sleeve-type flexible coupling.
   2. Products and Manufacturers: Provide one of the following:
      a. Style 128, as manufactured by Dresser Piping Specialties, part of Dresser, Inc.
      b. Style 913, by Smith Blair, Inc.
      c. Or equal.
   3. Pressure and Service: Same as connected piping.
   4. Material: Ductile iron.
   5. Gasket: Recommended by the manufacturer.

6. Bolts and Nuts: Alloy steel, corrosion-resistant, primer-coated. For buried or submerged applications, provide stainless steel bolts complete with washers complying with ASTM F593, AISI Type 316 and nitrided stainless nuts.
7. Harnessing:
    a. Harness adapters to restrain pressure piping. For pressure pipelines, test pressures are included in piping schedules in Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.
    b. For flanged adapters 12-inch diameter and smaller, provide 1/2-inch diameter (minimum) Type 316 stainless steel anchor studs installed in pressure-tight anchor boss. For buried or submerged applications, provide external bolting and other hardware of Type 316 stainless steel, including tie bolts, bolt plates, lugs, nuts, and washers. Provide number of studs required to restrain test pressure and service conditions. Harness shall be as designed and recommended by flanged adapter manufacturer. Provide the following minimum anchor studs unless otherwise approved by ENGINEER.
        1) Six-inch Diameter and Smaller: Two
        2) Eight-inch Diameter and Smaller: Four
        3) Ten-inch Diameter and Smaller: Six
        4) Twelve-inch Diameter and Smaller: Eight
    c. For adapters larger than 12-inch diameter, provide split-ring harness clamps with minimum of four corrosion-resistant alloy steel bolts. For buried or submerged applications, provide external bolting and other hardware of Type 316 stainless steel, including tie bolts, bolt plates, lugs, nuts, and washers. Harness assembly shall be as designed and recommended by flanged adapter manufacturer. Dimensions, sizes, spacing and materials shall be suitable for service and conditions encountered and shall be approved by ENGINEER.

C. Restraint Steel Sleeve Couplings:
1. Pressure and Service: Same as connected piping.
2. Products and Manufacturers: Provide products of one of the following:
    a. Style 471, by Smith Blair, Inc.
    b. Or equal.
3. Sleeve: ASTM A283 carbon steel with fusion bonded epoxy
4. Joint Restraint: ASTM A536 ductile iron gland and actuating bolts with single tooth ductile iron wedges with break away nuts.
5. Gaskets: Suitable for specified service, as recommended by manufacturer.
6. Studs and Nuts: High strength low alloy steel, corrosion-resistant, primer-coated. For buried or submerged applications, provide Type 304 stainless steel bolts complete with washers complying with nitrided stainless nuts.

2.2 EXPANSION JOINTS

A. Rubber-type Expansion Joints and Eccentric Expansion Joints:
   1. General:
      a. Use rubber-type expansion joints at all expansion joint locations, except where other types of expansion joints are shown or specified.
   2. Manufacturers: Provide products of one of the following:
      a. Mercer Rubber Company.
      b. U.S. Rubber Supply Company, USA
      c. Or equal.
   3. Liquid Service:
      a. Construct expansion joints of neoprene or Buna-N suitable for temperatures up to 180 degrees F.
      b. Expansion joints shall be filled arch type. Provide backup or retaining rings as recommended by expansion joint manufacturer.
      c. Expansion joints shall be yoked in manner to provide transmission of tension loading to which expansion joint may be subjected during system operation. Compressive or lateral movement of expansion joint shall not be impaired by yoking system. Details of expansion joint yoking shall be submitted to ENGINEER for approval.

2.3 EXPANSION JOINTS

A. Dismantaling Joints:
   1. Joints shall be a self-contained flanged restrained joint fitting, including both flanged components and sufficient harness bars to withstand operating conditions of piping system.
   2. Joints shall be provided for valves as indicated in the Valve Schedule in Section 15100, Valves and Appurtenances.
   3. Joints shall conform to AWWA C219.
   4. Pressure and Service: Same as connected piping.
   5. Materials:
      a. Spigot piece: ASTM A283 Steel.
      b. Flange Adapter: Ductile Iron or ASTM A 283 Steel.
      c. Tie bars: ASTM A 193 Grade B7 threaded rod with rolled ends.
      d. Gaskets: Suitable for potable water use.
      e. Coating: NSF approved.
   6. Manufacturer:
      a. Viking Johnson, A Glynwed Pipe Systems Ltd.
      b. Smith-Blair, Inc., Series 975.
      c. Or Equal.

2.4 MISCELLANEOUS SPECIALTIES AND ACCESSORIES

A. Dielectric Connections:

1. General: Where copper pipe connects to steel pipe, cast-iron pipe, or ductile iron pipe, provide either dielectric union or an insulating section of rubber or plastic pipe. When used, insulating section shall have minimum length of 12 pipe diameters.
2. Manufacturers: Provide products of one of the following:
   a. Epco Sales, Inc.
   b. Watts Regulator Company.
   c. Capitol Manufacturing Company.
   d. Or equal.
3. Dielectcric Unions: Rated for 250 psi, ANSI B16.39.
4. Insulating Sections: Rated for same pressure as associated piping test pressure. Material shall be suitable for the application and service.

2.5 IDENTIFICATION

A. Stamp, mark, or identify all couplings with the following:
   1. Name of manufacturer.
   2. Date of manufacturer.
   3. Operating design pressure at operating design temperature.
   4. Type of service.
   5. Manufacturer's part number.

2.6 PAINTING

A. Shop Painting:
   1. Clean and prime-coat ferrous metal surfaces of products in the manufacturer's shop in accordance with Section 09910, Painting, unless otherwise specified in this Section
   2. Coat machined, polished and non-ferrous surfaces bearing surfaces and similar unpainted surfaces with corrosion prevention compound that shall be maintained during storage and until products are placed into operation.

B. Field painting shall conform to Section 09910, Painting.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect materials for defects in material and workmanship. Verify compatibility of products with pipe, fittings, valves, and appurtenances.

3.2 INSTALLATION

A. Installation:

1. Install piping specialties in accordance with the Contract Documents and manufacturer's instructions.
2. For buried installations, refer to Section 15051, Buried Piping Installation.
3. For exposed installations, refer to Section 15052, Exposed Piping Installation.

B. Adjust expansion joints as required to ensure that expansion joints will be fully extended when ambient temperature is at minimum operating temperature, and fully compressed at maximum operating temperature for the system in which expansion joints are installed.

+ + END OF SECTION + +

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SECTION 15121

WALL PIPES, FLOOR PIPES AND PIPE SLEEVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install all floor pipes, pipe sleeves, wall pipes, other wall pieces, and escutcheons to complete the Work.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate with the installation of floor pipes, pipe sleeves, wall pipes, other wall pieces and escutcheons that must be installed with or within formwork, walls, partitions, ceilings and panels.

C. Related Sections:
   1. Section 03300, Cast-In-Place Concrete.
   2. Division 7, Sections on Sealants – Thermal & Moisture Protection.
   3. Division 15, Sections on Piping, Valves, Specials and Gates (Mechanical).

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American National Standards Institute, (ANSI).
      a. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings.
      b. ANSI B16.4, Gray-Iron Threaded Fittings.
   2. American Water Works Association, (AWWA).
      a. AWWA C104 (ANSI A21.4), Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
      b. AWWA C110 (ANSI A21.10), Ductile-Iron and Gray-Iron Fittings, for Water.
      c. AWWA C111 (ANSI A21.11), Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
      d. AWWA C115 (ANSI A21.15), Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
      e. AWWA C151 (ANSI A21.51), Ductile-Iron Pipe, Centrifugally Cast, for Water.
      f. AWWA C200, Steel Water Pipe 6-Inches and Larger.

1.3 QUALITY ASSURANCE

A. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single wall pipes, floor pipes and pipe sleeves manufacturer.
   2. The wall pipes, floor pipes and pipe sleeves manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall assembly by the wall pipes, floor pipes and pipe sleeves manufacturer.

1.4 SUBMITTALS

A. Shop Drawings: Submit the following:
   1. Detailed drawings and data on all wall and floor pipe, and pipe sleeves. Submit and coordinate these with Shop Drawings required for all piping systems.

1.5 DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements of Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Wall and Floor Pipes:
   1. Material: Same as specified for the piping connected to wall or floor pipe, unless otherwise approved by ENGINEER.
   2. End Connections: As shown.
   3. Thickness: Same as specified for the piping connected to wall or floor pipe.
   4. Collars: Provide collars at mid-point of wall for anchorage and watertightness.
   5. Pipes ends shall be flush with wall face, unless otherwise shown.
   6. Drill and tap flanged ends and mechanical joint bells for studs. Provide studs of same material as connected piping, except submerged and buried studs shall be of Type 316 stainless steel.

B. Pipe Sleeves:
   1. Pipe sleeves are required where shown on the Drawings.
   2. Sleeve shall conform to the applicable requirements of AWWA C219.
   3. Gaskets: NSF 61 Compounded.
   4. Bolts and Nuts: Stainless Steel.

5. Finish: Fusion bonded epoxy.
6. Manufacturer: Provide pipe sleeves of one of the following:
   a. Smith Blair
   b. Romac Industries, Inc.
7. Where restrained pipe sleeves are required, restrain with Meg-a-Lug.
8. Pressure rating shall be 250 psi working pressure.
9. Copper Pipe: Use Type K hard drawn copper pipe, unless otherwise shown.

C. Cast Wall Sleeves:
   1. Material: Ductile iron furnished with integral wall collar.
   2. Dimensions: As required for mechanical joint pipe to pass through sleeve. Length as required.

D. Link Seals: Provide link type mechanical seals suitable for 20 psi working pressure, corrosive service and accessible from one side, with glass-reinforced nylon pressure plate and stainless steel bolts and nuts.
   1. Products and Manufacturers: Provide one of the following:
      a. Link-Seal, as manufactured by Thunderline Corporation.
      b. Or equal.

E. Wall and Ceiling Plates:
   1. Bare pipes passing through walls and ceilings in finished rooms: Provide escutcheon plates of cast brass or cast-iron nickel plated, clevis or split ring and hinged with set screws.
   2. Provide plated escutcheon plates of 18-gauge steel for insulated pipes passing through walls and ceilings in finished rooms.

F. Prestressed Concrete Pressure Pipe to Ductile Iron Pipe Adapters:
   1. Steel thickness of all adapter fittings shall be designed in accordance with Chapter 8 of the AWWA M9 Manual for Concrete Pressure Pipe. Adapter fittings shall be designed for the same conditions as the adjacent pipe.
   2. Fabrication of the adapters shall be as per AWWA M9 Manual and the AWWA C301 Standard for the Manufacture of Prestressed Concrete Cylinder Pipe.
   3. Interior and exterior concrete/mortar coating shall be as per the AWWA C301 standard.

G. PCCP Tapping Saddle:
   1. Construction: ASTM A 285 Grade C steel or equal.
   2. Waterway shall be lined with fusion bonded epoxy to minimum thickness of 15 mils in accordance with AWWA C213.
   3. Hardware shall be type 304, stainless steel.
   4. End Connections: Flanged.
   5. Pressure Rating: 250 psi.
   6. Manufacturer:
      a. HydraStop, Inc.

b. Price Brothers (Hanson).
c. Or Approved Equal.

H. Tapping Sleeve for Ductile Iron Pipe:
1. General: Mechanical Joint Tapping Sleeve designed for use on Ductile Iron or Gray Iron Pipe.
2. Pressure Rating: 200 psi
3. Materials:
a. Body: Cast Iron.
b. Gaskets: Rubber.
c. Hardware: Type 304 Stainless Steel.
4. Manufacturer and Model:
a. U.S. Pipe, H-615.
b. Smith-Blair, Style 623.
c. Or Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall and Floor Pipes: Install as shown and in accordance with approved Shop Drawings.

B. Pipe Sleeves:
1. Use sleeves wherever pipes pass through walls, partitions, floors, and roofs, unless otherwise shown.
2. Extend all sleeves through floor slabs a minimum of 2-inches above finished floor.
3. Anchor sleeves to concrete and masonry walls as shown or otherwise approved.
4. All sleeves through walls shall be flush with wall face.
5. All pipe joints and annular spaces in exterior walls or walls subjected to hydrostatic pressure shall be completely watertight.
6. Use link type seals to seal sleeve against hydrostatic pressure. Size sleeves to provide annular space required to suit the link type mechanical seals that are used.
7. Do not install sleeves and pipes through structural members, unless specifically shown and approved by ENGINEER.
8. Size sleeves to provide annular space as follows:

Pipe Size	Sleeve ID Minus Pipe Or Insulation OD
Less than 2-inches	1/2-inches to 3/4-inches
2-inches to 4-inches	3/4 inches to 1-1/4-inches.

6-inches to 12-inches	1-1/4 inches to 2-inches
Over 12-inches	2-inches to 3-inches

C. Install wall and ceiling plates in accordance with the manufacturer's recommendations and approved Shop Drawings.

3.2 MANUFACTURER'S SERVICES

A. CONTRACTOR shall provide the services of a qualified Price Brothers (Hanson) Company crew to perform the installation of the following PCCP taps before the valves are put into operation:
   1. Taylor Mill Treatment Plant:
      a. 24-inch PCCP Line Taps
         1) 12-inch tap (total of 1)
         2) Tap for insert flow meter, size to be coordinated with meter provided.

B. Prior to ordering material:
   1. Determine:
      a. Manufacturer;
      b. Year of manufacturer;
      c. Cross-sectional dimensions.
   2. Excavate, expose, and clean the exterior of the main at the location of the tap.
      a. Measure circumference.
      b. Chip concrete away to the steel cylinder to determine reinforcement and depth of mortar coating. Be careful not to damage prestressing wire.
      c. Restore mortar coating and backfill.
   3. Verify that location of tap is not near existing joint.

C. Re-excavate and clean pipe in area where saddle is to be installed. Remove any irregularities extending beyond the normal contour of the pipe surface. Check all measurements to be certain saddle is correct size for the pipe.

D. Position gland on the pipe and mark the area where the mortar coating is to be removed.

E. Remove gland and set aside. Carefully remove mortar coating from area where tap is to be made – exposing but not damaging the prestress wires and steel cylinder.

F. Check to make certain all grout gaskets are in place around the edge of the saddle over the opening in the mortar coating (with the grouting openings up) and install the straps. Tighten straps with only sufficient torque to lightly seal the grout gaskets, alternating from one side of the saddle to the other – starting at the outside straps and working in toward the center.

G. Pour cement grout into the grout horns in the saddle filling the space between the saddle and the pipe. Pound the saddle with a hammer to vibrate the grout into place. After the grout has set, tighten the bolts on the straps.

H. Carefully cut and remove the exposed prestress wires to provide clearance for the gland to seal against the cylinder. For embedded cylinder pipe, the outer portion of the concrete core must be removed to expose the cylinder. Clean the steel cylinder surface of any remaining concrete. (Note: If there is a weld seam on the cylinder of the pipe in the area of the tap, carefully flatten the weld so that the tapping gland gasket will seal on it. Do not grind the weld.)

I. Check the gasket in the gland to make certain it is undamaged and in its retaining groove. Remove any tape used to secure the gasket in place during shipment.

J. Install the four threaded studs in the saddle outlet to assist in properly aligning the gland. Install the gland in the saddle outlet so that the contour of the gasket seat exactly matches the contour of the steel cylinder. Install the remainder of the draw bolts. Check the gasket seat and all alignment. Tighten the draw bolts evenly to compress the gasket. A feeler gauge can be used to check gasket position during tightening. When completely tightened there should be approximately 1/8" between the gasket seat and the pipe cylinder.

K. After installation of the tapping gland, tighten the load bearing set screws located between the draw bolts of the outer circle. This locks the gland in place and transfers any loading from the outlet onto the saddle and away from the cylinder.

L. Install the tapping valve utilizing the inner circle of studs and nuts furnished with the gland.

M. Use water to pressure test the gland seal, flange gaskets, and tapping valve to assure all joints are tight and gaskets properly seated. Use a 250 psi capacity pressure gauge to test at 110% of operating pressure.

N. Mount the tapping machine to the valve. Open the valve completely. Advance the cutter by means of the hand screw through the open valve. Apply power, and the pilot drill will begin to cut the cylinder. Resistance will increase when the shell cutter contacts the pipe cylinder. When the automatic feed screw has advanced to a predetermined distance, the cut is complete.

O. Withdraw the cutting head past the gate and close the valve. Disconnect the tapping machine.

P. On completion of the tap, pour cement mortar mix (two parts sand, one part cement) into the opening between the gland and the saddle, and into the grouting hole in the saddle neck, completely filling the space around the gland. Encase the

saddle in a protective coating of cement mortar or concrete to a minimum thickness of 1” over the entire assembly including the straps.

Q. Provide thrust blocking and a permanent support beneath the valve.

+ + END OF SECTION + +

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SECTION 15126

METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Filled-system thermometers.
   2. Liquid-in-glass thermometers.
   3. Thermowells.
   4. Gage attachments.
   5. Test plugs.
   6. Test-plug kits.
   7. Sight flow indicators.

B. Related Sections:
   1. Division 2 Section "Water Distribution" for domestic water meters and combined domestic and fire-protection water-service meters outside the building.
   2. Division 2 Section "Facility Fire-Suppression Water-Service Piping" for fire-protection water-service meters outside the building.
   3. Division 13 fire-suppression piping Sections for fire-protection pressure gages.
   4. Division 15 Section "Domestic Water Piping" for water meters inside the building.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:

1 Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ashcroft Inc.
   b. Miljoco Corporation.
   c. REOTEMP Instrument Corporation.
2. Standard: ASME B40.200.
3. Case: Sealed type, plastic 6-inch (152-mm) nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Pointer: Dark-colored metal.
8. Window: Plastic.
9. Ring: Plastic.
10. Connector Type(s): Union joint; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
    a. Design for Thermowell Installation: Bare stem.
12. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flo Fab Inc.
      b. Miljoco Corporation.
      c. Tel-Tru Manufacturing Company.
      d. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
      e. Weiss Instruments, Inc.
      f. WIKA Instrument Corporation - USA.
   2. Standard: ASME B40.200.
   3. Case: Plastic; 6-inch (152-mm) nominal size.
   4. Case Form: Straight.
   5. Tube: Glass with magnifying lens and red organic liquid.
   6. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F and deg C.
   7. Window: Glass or plastic.
   8. Stem: Aluminum or brass and of length to suit installation.
      a. Design for Thermowell Installation: Bare stem.
   9. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
   10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ernst Flow Industries.
      b. Marsh Bellofram.
      c. Miljoco Corporation.
      d. Palmer Wahl Instrumentation Group.

e. REOTEMP Instrument Corporation.
f. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
g. Weiss Instruments, Inc.
h. WIKA Instrument Corporation - USA.

2. Standard: ASME B40.200.
3. Case: Plastic 9-inch (229-mm) nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Plastic
8. Stem: Aluminum, brass, or stainless steel and of length to suit installation.
   a. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 THERMOWELLS

A. Thermowells:
   1. Standard: ASME B40.200.
   2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
   3. Material for Use with Copper Tubing: CNR.
   4. Type: Stepped shank unless straight or tapered shank is indicated.
   5. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
   6. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
   7. Bore: Diameter required to match thermometer bulb or stem.
   8. Insertion Length: Length required to match thermometer bulb or stem.
   9. Lagging Extension: Include on thermowells for insulated piping and tubing.
   10. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.4 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, with NPS 1/4 (DN 8), ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flow Design, Inc.

2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 (DN 8), ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).

F. Core Inserts: EPDM self-sealing rubber.

2.6 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).

F. Carrying Case: Metal or plastic, with formed instrument padding.

2.7 SIGHT FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Archon Industries, Inc.
   2. Dwyer Instruments, Inc.
   3. Emerson Process Management; Brooks Instrument.
   4. Ernst Co., John C., Inc.
   5. Ernst Flow Industries.
   6. KOBOLD Instruments, Inc. - USA; KOBOLD Messring GmbH.
   7. OPW Engineered Systems; a Dover company.
   8. Penberthy; A Brand of Tyco Valves & Controls - Prophetstown.

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 150 psig (1034 kPa).

E. Minimum Temperature Rating: 200 deg F (93 deg C).

F. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

G/ End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D/ Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install remote-mounted pressure gages on panel.

I. Install valve and snubber in piping for each pressure gage for fluids.

J. Install test plugs in piping tees.

K. Install thermometers in the following locations:
   1. Inlet and outlet of each water heater.
   2. Inlet and outlet of each domestic hot-water storage tank.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
   1. Direct-mounted, plastic-case, vapor-actuated type.
   2. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be one of the following:
   1. Direct-mounted, plastic-case, vapor-actuated type.
   2. Test plug with EPDM self-sealing rubber inserts.

C. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C).

+ + END OF SECTION + +

SECTION 15140

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.
   2. Encasement for piping.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Construction Manager. Owner no fewer than two days in advance of proposed interruption of water service.
   2. Do not interrupt water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) and ASTM B 88, Type M (ASTM B 88M, Type C) water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) and ASTM B 88, Type L (ASTM B 88M, Type B) water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:
   1. MSS SP-123.
   2. Cast-copper-alloy, hexagonal-stock body.
   3. Ball-and-socket, metal-to-metal seating surfaces.
   4. Solder-joint or threaded ends.

2.3 STAINLESS-STEEL PIPING

A. Potable-water piping and components shall comply with NSF 61.

B. Stainless-Steel Pipe: ASTM A 312/A 312M, Schedule 40.

C. Stainless-Steel Pipe Fittings: ASTM A 815/A 815M.

D. Appurtenances for Grooved-End, Stainless-Steel Pipe:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International.
      b. Grinnell Mechanical Products; Tyco Fire Products LP.
      c. Shurjoint Piping Products.
      d. Victaulic Company.
   2. Fittings for Grooved-End, Stainless-Steel Pipe: Stainless-steel casting with dimensions matching stainless-steel pipe.
   3. Mechanical Couplings for Grooved-End, Stainless-Steel Pipe:
      a. AWWA C606 for stainless-steel-pipe dimensions.

b. Stainless-steel housing sections.
c. Stainless-steel bolts and nuts.
d. EPDM-rubber gaskets suitable for hot and cold water.
e. Minimum Pressure Rating:
1) NPS 8 (DN 200) and Smaller: 600 psig (4137 kPa).
2) NPS 10 and NPS 12 (DN 250 to DN 300): 400 psig (2758 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600): 250 psig (1725 kPa).

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
1. AWWA C110/A21.10, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

F. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
1. CPVC solvent cement shall have a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.5 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105/A21.5.

2.6 TRANSITION FITTINGS

A. General Requirements:
1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.

3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cascade Waterworks Manufacturing.
      b. Dresser, Inc.; Piping Specialties Products.
      c. Ford Meter Box Company, Inc. (The).
      d. JCM Industries.
      e. Romac Industries, Inc.
      f. Smith-Blair, Inc.; a Sensus company.
      g. Viking Johnson.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Capitol Manufacturing Company; member of the Phoenix Forge Group.
      b. Central Plastics Company.
      c. Hart Industries International, Inc.
      d. Jomar International.
      e. Matco-Norca.
      f. McDonald, A. Y. Mfg. Co.
      g. Watts; a division of Watts Water Technologies, Inc.
      h. Wilkins; a Zurn company.
   2. Standard: ASSE 1079.
   3. Pressure Rating: 150 psig (1035 kPa).
   4. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Capitol Manufacturing Company; member of the Phoenix Forge Group.
      b. Central Plastics Company.
      c. Matco-Norca.
      d. Watts; a division of Watts Water Technologies, Inc.
      e. Wilkins; a Zurn company.

2. Standard: ASSE 1079.
3. Factory-fabricated, bolted, companion-flange assembly.
4. Pressure Rating: 150 psig (1035 kPa)
5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.
2. Nonconducting materials for field assembly of companion flanges.
3. Pressure Rating: 150 psig (1035 kPa).
4. Gasket: Neoprene or phenolic.
5. Bolt Sleeves: Phenolic or polyethylene.
6. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Elster Perfection Corporation.
b. Grinnell Mechanical Products; Tyco Fire Products LP.
c. Matco-Norca.
d. Precision Plumbing Products, Inc.
e. Victaulic Company.
2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. Pressure Rating and Temperature: 300 psig (2070 kPa) at 225 deg F (107 deg C).
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design

considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Division 15 Section "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Division 15 Section "Domestic Water Piping Specialties."

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Division 15 Section "Domestic Water Piping Specialties."

H .Install domestic water piping level and plumb.

I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Division 15 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

L. 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.

M. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

N. Install piping to permit valve servicing.

O. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

P. Install piping free of sags and bends.

Q. Install fittings for changes in direction and branch connections.

R. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

S. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Division 15 Section "Meters and Gages for Plumbing Piping."

T. Install thermometers on outlet piping from each water heater. Comply with requirements for thermometers in Division 15 Section "Meters and Gages for Plumbing Piping."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 15 Section "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 15 Section "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 15 Section "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. 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.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

H. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100). Use dielectric nipples.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Division 15 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Division 15 Section "Hangers and Supports for Plumbing Piping and Equipment."
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.

b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.

F. Install supports for vertical copper tubing every 10 feet (3 m).

G. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.

H. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.

2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code. Comply with requirements for connection sizes in Division 15 plumbing fixture Sections.
4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Division 15 Section "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Piping Inspections:
      a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
      b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
         1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
         2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
      c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
      d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
   2. Piping Tests:
      a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
      b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.

c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:
1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Fill and isolate system according to either of the following:
1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.
c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Repeat procedures if biological examination shows contamination.
e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Clean non-potable domestic water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, NPS 3 (DN 80) and smaller, shall be the following:
1. Hard copper tube, ASTM B 88, Type K (ASTM B 88M, Type A); wrought-copper, solder-joint fittings; and brazed joints.

E. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B) wrought-copper, solder-joint fittings; and soldered joints.
   2. CPVC, Schedule 40; socket fittings; and solvent-cemented joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use ball valves for piping NPS 2 (DN 50) and smaller.
   2. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

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SECTION 15145

DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Vacuum breakers.
   2. Backflow preventers.
   3. Water pressure-reducing valves.
   4. Temperature-actuated, water mixing valves.
   5. Strainers.
   6. Hose bibbs.
   7. Wall hydrants.
   8. Water-hammer arresters.
   9. Flexible connectors.
   10. Water Meters.

B. Related Requirements:
   1. Division 15 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
   2. Division 15 Section "Domestic Water Piping" for water meters.
   3. Division 15 Section "Emergency Plumbing Fixtures" for water tempering equipment.
   4. Division 15 Section "Pressure Water Coolers" for water filters for water coolers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.
   1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 and NSF 14. Mark "NSF-pw" on plastic piping components.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig (860 kPa) unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
      b. Cash Acme; a division of Reliance Worldwide Corporation.
      c. Conbraco Industries, Inc.
      d. FEBCO; a division of Watts Water Technologies, Inc.
      e. Rain Bird Corporation.
      f. Toro Company (The); Irrigation Div.
      g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      h. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   2. Standard: ASSE 1001.
   3. Size: NPS 1/4 to NPS 3 (DN 8 to DN 80), as required to match connected piping.
   4. Body: Bronze.
   5. Inlet and Outlet Connections: Threaded.
   6 Finish: Rough bronze.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrowhead Brass Products.
      b. Cash Acme; a division of Reliance Worldwide Corporation.
      c. Conbraco Industries, Inc.
      d. Legend Valve.

e. MIFAB, Inc.
f. Prier Products, Inc.
g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
h. Woodford Manufacturing Company; a division of WCM Industries, Inc.
i. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
j. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.

2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Rough bronze.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers (1 1/2"):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
b. Conbraco Industries, Inc.
c. FEBCO; a division of Watts Water Technologies, Inc.
d. Flomatic Corporation.
e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig (83 kPa) maximum, through middle third of flow range.
5. Size: 1-1/2 inch.
6. Design Flow Rate: 40 gpm.
7. Selected Unit Flow Range Limits: 0 – 47 gpm.
8. Pressure Loss at Design Flow Rate: 12 psi for sizes NPS 2 (DN 50) and smaller.
9. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
10. End Connections: Threaded for NPS 2 (DN 50) and smaller.
11. Configuration: Designed for horizontal, straight-through flow.
12. Accessories:
a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.

b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Reduced-Pressure-Principle Backflow Preventers (4”):
1. Manufacturers: Subject to compliance with requirements.
a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
b. Conbraco Industries, Inc.
c. FEBCO; a division of Watts Water Technologies, Inc.
d. Flomatic Corporation.
e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig (83 kPa) maximum, through middle third of flow range.
5. Size: 4”
6. Design Flow Rate: 200 GPM.
7. Selected Unit Flow Range Limits: 0 – 600 GPM.
8. Pressure Loss at Design Flow Rate: 9 psig for NPS 2-1/2 (DN 65) and larger.
9 Body: Stainless steel for NPS 2-1/2 (DN 65) and larger.
10. End Connections: Flanged for NPS 2-1/2 (DN 65) and larger.
11. Configuration: Designed for horizontal, straight-through flow.
12. Accessories:
a. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Cash Acme; a division of Reliance Worldwide Corporation.
b. Conbraco Industries, Inc.
c. Honeywell International Inc.
d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig (1035 kPa).
4. Size: 1 1/2 inch.

5. Design Flow Rate: 40 gpm.
6. Design Inlet Pressure: N/A.
7. Design Outlet Pressure Setting: 60 psig.
8. Body: Bronze for NPS 2 (DN 50) and smaller.
9. End Connections: Threaded for NPS 2 (DN 50) and smaller.

B. Water-Control Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CLA-VAL.
   b. Flomatic Corporation.
   c. OCV Control Valves.
   d. Watts; a division of Watts Water Technologies, Inc.; Control Valves (Watts ACV).
   e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   f. Approved Equal.
2. Description: Pilot-operated, diaphragm-type, single-seated, main water-control valve.
3. Pressure Rating: Initial working pressure of 150 psig (1035 kPa) minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
   a. Size: 4 inch.
   b. Pattern: Globe-valve design.
   c. Trim: Stainless steel.
5. Design Flow: 150 GPM.
6. Design Inlet Pressure: 210 psig.
7. Design Outlet Pressure Setting: 75 psig.
8. End Connections: Flanged for NPS 2-1/2 (DN65) and larger.

2.6 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Primary, Thermostatic, Water Mixing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong International, Inc.
   b Lawler Manufacturing Company, Inc.
   c. Leonard Valve Company.
   d. Powers; a division of Watts Water Technologies, Inc.
   e. Symmons Industries, Inc.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
4. Type: Stainless steel, cabinet, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.

6. Connections: Threaded inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: See Plans.
9. Tempered-Water Design Flow Rate: See Plans.
10. Pressure Drop at Design Flow Rate: See Plans.
11. Valve Finish: Rough bronze.
12. Piping Finish: Copper.
13. Cabinet: Factory fabricated, stainless steel, for surface mounting and with hinged, stainless-steel door.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
1. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 (DN 50) and smaller.
3. End Connections: Threaded for NPS 2 (DN 50) and smaller.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
   a. Strainers NPS 2 (DN 50) and Smaller: 0.033 inch (0.84 mm).
6. Drain: Factory-installed, hose-end drain valve.

2.8 HOSE BIBBS

A. Hose Bibbs:
1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig (860 kPa).
7. Vacuum Breaker: Field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.
13. Operation for Finished Rooms: Wheel handle.
14. Include operating key with each operating-key hose bibb.
15. Include wall flange with each chrome- or nickel-plated hose bibb.

2.9 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Josam Company.
    b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    c. Watts Drainage Products.
    d. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
    e. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig (860 kPa).
4 Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Chrome plated.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Rough bronze.
12. Operating Keys(s): Four with each wall hydrant.

2.10 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. AMTROL, Inc.
        b. Josam Company.
        c. MIFAB, Inc.
        d. Precision Plumbing Products, Inc.
        e. Sioux Chief Manufacturing Company, Inc.
        f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
        g. Tyler Pipe; Wade Div.
        h. Watts Drainage Products.
        i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
    2. Standard: ASSE 1010 or PDI-WH 201.
    3. Type: Copper tube with piston.
    4. Size: ASSE 1010, PDI-, Size A.

2.11 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flex-Hose Co., Inc.
   2. Flexicraft Industries.
   3. Flex Pression, Ltd.
   4. Flex-Weld Incorporated.
   5. Hyspan Precision Products, Inc.
   6. Mercer Gasket & Shim, Inc.
   7. Metraflex, Inc.
   8. Proco Products, Inc.
   9. TOZEN Corporation.
   10. Unaflex.
   11. Universal Metal Hose; a Hyspan company.

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   1. Working-Pressure Rating: Minimum 200 psig (1380 kPa).
   2. End Connections NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.

2.12 WATER METERS

A. Compound-Type Water Meters:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB.
      b. Badger Meter, Inc.
      c. Master Meter, Inc.
      d. Mueller Co. Ltd.; a subsidiary of Mueller Water Products, Inc.
      e. Schlumberger Limited; Water Services.
      f. Sensus.
   2. Description:
      a. Standard: AWWA C702.
      b. Pressure Rating: 150-psig (1035-kPa) working pressure.
      c. Body Design: With integral mainline and bypass meters; totalization meter.
      d. Registration: In gallons (liters) or cubic feet (cubic meteres) as required by utility company.
      e. Case: Bronze.
      f. Pipe Connections: Flanged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
   3. Do not install bypass piping around backflow preventers.

B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

C. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified.

D. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve.

E. Install water-hammer arresters in water piping according to PDI-WH 201.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for ground equipment in Division 16 Section "Grounding and Bonding."

C. Fire-retardant-treated-wood blocking is specified in Division 16 Section "Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Pressure vacuum breakers.
   2. Reduced-pressure-principle backflow preventers.
   3. Water pressure-reducing valves.
   4. Primary, thermostatic, water mixing valves.
   5. Hose stations.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 15 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test each pressure vacuum breaker, and reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

+ + END OF SECTION + +

SECTION 15150

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.
   3. Encasement for underground metal piping.

B. Related Sections:
   1. Division 2 Section "Sanitary Sewerage" for sanitary sewerage piping and structures outside the building.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water (30 kPa).

B. Seismic Performance: See Structural Plans.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For solvent drainage system. Include plans, elevations, sections, and details.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect, Construction Manager, Owner no fewer than two days in advance of proposed interruption of sanitary waste service.
   2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class(es).

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.

C. CISPI, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   b. Dallas Specialty & Mfg. Co.
   c. Fernco Inc.
   d. Matco-Norca, Inc.
   e. MIFAB, Inc.
   f. Mission Rubber Company; a division of MCP Industries, Inc.
   g. Stant.
   h. Tyler Pipe.
2. Standards: ASTM C 1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
4. ASTM C 564, rubber sleeve with integral, center pipe stop.

D. Cast-Iron, Hubless-Piping Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. MG Piping Products Company.
2. Standard: ASTM C 1277.
3. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 DUCTILE-IRON PIPE AND FITTINGS

A. Ductile-Iron, Mechanical-Joint Piping:
1. Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Ductile-Iron Fittings: AWWA C110/A21.10, mechanical-joint, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
3. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Ductile-Iron, Push-on-Joint Piping:
1. Ductile-Iron Pipe: AWWA C151/A21.51, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Ductile-Iron Fittings: AWWA C110/A21.10, push-on-joint ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
3. Gaskets: AWWA C111/A21.11, rubber.

2.5 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.
   1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Solvent Cement: ASTM D 2564.
   1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
   1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
   2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
   3. Unshielded, Nonpressure Transition Couplings:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Dallas Specialty & Mfg. Co.
         2) Fernco Inc.
         3) Mission Rubber Company; a division of MCP Industries, Inc.
         4) Plastic Oddities; a division of Diverse Corporate Technologies, Inc.
      b. Standard: ASTM C 1173.
      c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
      d. Sleeve Materials:
         1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
         2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
         3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
   4. Shielded, Nonpressure Transition Couplings:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Cascade Waterworks Mfg. Co.
2) Mission Rubber Company; a division of MCP Industries, Inc.

b. Standard: ASTM C 1460.

c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

5. Pressure Transition Couplings:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Cascade Waterworks Mfg. Co.
2) Dresser, Inc.
3) EBAA Iron, Inc.
4) JCM Industries, Inc.
5) Romac Industries, Inc.
6) Smith-Blair, Inc.; a Sensus company.
7) The Ford Meter Box Company, Inc.
8) Viking Johnson.

b. Standard: AWWA C219.

c. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.

d. Center-Sleeve Material: Stainless steel.

e. Gasket Material: Natural or synthetic rubber.

f. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

2. Dielectric Unions:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Capitol Manufacturing Company.
2) Central Plastics Company.
3) Hart Industries International, Inc.
4) Jomar International Ltd.
5) Matco-Norca, Inc.
6) McDonald, A. Y. Mfg. Co.
7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
8) Wilkins; a Zurn company.

b. Description:
1) Standard: ASSE 1079.
2) Pressure Rating: Minimum at 180 deg F (82 deg C), 150 psig (1035 kPa).
3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Nipples:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Elster Perfection.
2) Grinnell Mechanical Products.
3) Matco-Norca, Inc.
4) Precision Plumbing Products, Inc.
5) Victaulic Company.

b. Description:
1) Standard: IAPMO PS 66
2) Electroplated steel nipple.
3) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
4) End Connections: Male threaded or grooved.
5) Lining: Inert and noncorrosive, propylene.

2.7 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A 674 or AWWA C105/A 21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) minimum thickness.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Division 2 Section "Earthwork."

3.2 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 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. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

L. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
   1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
   2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

O. Install aboveground PVC piping according to ASTM D 2665.

P. Install underground PVC piping according to ASTM D 2321.

Q. Install engineered soil and waste drainage and vent piping systems as follows:
   1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
   2. Sovent Drainage System: Comply with ASSE 1043 and sovent fitting manufacturer's written installation instructions.
   3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

R. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside building between wall and floor penetrations and connection to sanitary sewer piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
   1. Install encasement on piping according to ASTM A 674 or AWWA C105/A 21.5.

S. Install force mains at elevations indicated.

T. Plumbing Specialties:
   1. Install backwater valves in sanitary waster gravity-flow piping. Comply with requirements for backwater valves specified in Division 15 Section "Sanitary Waste Piping Specialties."
   2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 15 Section "Sanitary Waste Piping Specialties."
   3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 15 Section "Sanitary Waste Piping Specialties."

U. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 15 Section "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 15 Section "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 15 Section "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.

C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. 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.

E. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

F. Plastic, Nonpressure-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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in OD's.
   2. In Drainage Piping: Shielded, nonpressure transition couplings.
   3. In Aboveground Force Main Piping: Fitting-type transition couplings.
   4. In Underground Force Main Piping:
      a. NPS 1-1/2 (DN 40) and Smaller: Fitting-type transition couplings.
      b. NPS 2 (DN 50) and Larger: Pressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
   2. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.
   3. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flange kits.
   4. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Division 15 Section "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install fiberglass pipe hangers for horizontal piping in corrosive environments.
   3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
   5. Vertical Piping: MSS Type 8 or Type 42, clamps.
   6. Install individual, straight, horizontal piping runs:
      a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
   7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
   3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
   2. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
   3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.

I. Install supports for vertical PVC piping every 48 inches (1200 mm).

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
   5. Comply with requirements for cleanouts and drains specified in Division 15 Section "Sanitary Waste Piping Specialties."
   6. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:
   1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 15 Section "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa). Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
   5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   4. Prepare reports for tests and required corrective action.

3.9 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

3.10 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 (DN 100) and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings and sovent stack fittings hubless-piping couplings; and coupled joints.
   3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Aboveground, soil and waste piping NPS 5 (DN 125) and larger shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings and sovent stack fittings; hubless-piping couplings; and coupled joints.
   3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   4. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

D. Aboveground, vent piping NPS 4 (DN 100) and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings; hubless-piping couplings; and coupled joints.
   3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   4. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

E. Underground, soil, waste, and vent piping NPS 4 (DN 100) and smaller shall be any of the following:
   1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings; cast-iron hubless-piping couplings; and coupled joints.
   3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

F. Underground, soil and waste piping NPS 5 (DN 125) and larger shall be any of the following:
   1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings; cast-iron hubless-piping couplings; coupled joints.
   3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

+ + END OF SECTION + +

SECTION 15155

SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Cleanouts.
   2. Floor drains.
   3. Roof flashing assemblies.
   4. Through-penetration firestop assemblies.
   5. Miscellaneous sanitary drainage piping specialties.
   6. Flashing materials.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PVC: Polyvinyl chloride plastic.

1.4 ACTION SUBMITTALS

A. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.
   1. Wiring Diagrams: Power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. 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.

C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Cast-Iron Wall Cleanouts:
   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. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Standard: ASME A112.36.2M. Include wall access.
   3. Size: Same as connected drainage piping.
   4. Body: As required to match connected piping.
   5. Closure: Raised-head plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
   7. Wall Access: Round, cover plate with screw.
   8. Wall Access: Round wall-installation frame and cover.

B. Plastic Floor Cleanouts:
   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: (See Plumbing Specialties Schedule)

a. Canplas LLC.
b. IPS Corporation.
c. NDS Inc.
d. Plastic Oddities; a division of Diverse Corporate Technologies.
e. Sioux Chief Manufacturing Company, Inc.
f. Zurn Plumbing Products Group; Light Commercial Operation.

2. Type: Adjustable housing.
3. Size: Same as connected branch (4-inch maximum).
4. Body: Polyvinylidene Flouride (PVDF).
5. Closure Plug: Stainless steel scoriated; gas and water-tight tapered.
6. Riser: Drainage pipe fitting and riser to cleanout of same material as drainage piping.

2.2 FLOOR DRAINS

A. Plastic Floor Drains:
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. Canplas LLC.
b. IPS Corporation.
c. Josam Company; Josam Div.
d. Oatey.
e. Plastic Oddities; a division of Diverse Corporate Technologies.
f. Sioux Chief Manufacturing Company, Inc.
g. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.6.3.
3. Material: Polyvinylidene Flouride (PVDF).
4. Seepage Flange: Required.
5. Clamping Device: Required.
6. Outlet: Bottom.
7. Sediment Bucket: Required.
8. Top or Strainer Material: Stainless steel.
9. Top of Body and Strainer Finish: Stainless steel.
10. Top Shape: Round.
11. Dimensions of Top or Strainer: See Plumbing Specialties Schedule.
12. Trap Material: See Plumbing Drawings.
13. Trap Pattern: Standard P-trap.

2.3 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:
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. Acorn Engineering Company; Elmdor/Stoneman Div.
b. Thaler Metal Industries Ltd.

B. Description: Manufactured assembly made of 6.0-lb/sq. ft. (30-kg/sq. m), 0.0938-inch- (2.4-mm-) thick, lead flashing collar and skirt extending at least 10 inches (250 mm) from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
   1. Open-Top Vent Cap: Without cap.
   2. Low-Silhouette Vent Cap: With vandal-proof vent cap.
   3. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.4 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:
   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. ProSet Systems Inc.
   2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
   3. Size: Same as connected soil, waste, or vent stack.
   4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
   5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
   6. Special Coating: Corrosion resistant on interior of fittings.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:
   1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.

B. Deep-Seal Traps:
   1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
   2. Size: Same as connected waste piping.
      a. NPS 2 (DN 50): 4-inch- (100-mm-) minimum water seal.
      b. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) minimum water seal.

C. Air-Gap Fittings:
   1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
   2. Body: Bronze or cast iron.
   3. Inlet: Opening in top of body.
   4. Outlet: Larger than inlet.

5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Sleeve Flashing Device:
   1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches (51 mm) above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
   2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings:
   1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
   2. Size: Same as connected stack vent or vent stack.

F. Expansion Joints:
   1. Standard: ASME A112.21.2M.
   2. Body: Cast iron with bronze sleeve, packing, and gland.
   3. End Connections: Matching connected piping.
   4. Size: Same as connected soil, waste, or vent piping.

2.6 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft. (15-kg/sq. m), 0.0469-inch (1.2-mm) thickness.
   3. Burning: 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Applications: 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm thickness).
   2. Vent Pipe Flashing: 8 oz./sq. ft. (2.5 kg/sq. m or 0.27-mm thickness).

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness, unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil (1.01-mm) minimum thickness.

E. Fasteners: Metal compatible with material and substrate being fastened.

F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

G. Solder: ASTM B 32, lead-free alloy.

H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
   4. Locate at base of each vertical soil and waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
      b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
      c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.
   3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
   4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

E. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

F. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

G. Install through-penetration firestop assemblies in plastic stacks at floor penetrations.

H. Assemble open drain fittings and install with top of hub 2 inches (51 mm) above floor.

I. Install deep-seal traps on floor drains and other waste outlets, if indicated.

J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

K. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

L. Install vent caps on each vent pipe passing through roof.

M. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

N. Install wood-blocking reinforcement for wall-mounting-type specialties.

O. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness or thinner.
   2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 7 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

+ + END OF SECTION + +

SECTION 15183

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-407C:
   1. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
   2. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
   3. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).

B. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
   2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
   3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
   1. Thermostatic expansion valves.
   2. Solenoid valves.
   3. Hot-gas bypass valves.
   4. Filter dryers.
   5. Strainers.
   6. Pressure-regulating valves.

B. 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. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).

2. 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.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 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.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07720 "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L.

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 (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
   4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
   5. Maximum Operating Temperature: 250 deg F (121 deg C).

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 (3450 kPa).
   7. Maximum Operating Temperature: 275 deg F (135 deg C).

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 (3450 kPa).
   8. Maximum Operating Temperature: 275 deg F (135 deg C).

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 (3.4 kPa).

8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 deg F (135 deg C).

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 (3450 kPa).

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 (16-GRC) conduit adapter, and [24] [115] [208]-V ac coil.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).
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 (2760 kPa).
6. Maximum Operating Temperature: 240 deg F (116 deg C).

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 (4.4 deg C).
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 (4820 kPa).

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 115-V ac coil.
8. End Connections: Socket.
9. Throttling Range: Maximum 5 psig (34 kPa).
10. Working Pressure Rating: 500 psig (3450 kPa).
11. Maximum Operating Temperature: 240 deg F (116 deg C).

I. 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 (3450 kPa).
5. Maximum Operating Temperature: 275 deg F (135 deg C).

J. 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 (3450 kPa).
6. Maximum Operating Temperature: 275 deg F (135 deg C).

K. 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 (3450 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

L. 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 alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.

7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 240 deg F (116 deg C).

M. 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 alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 240 deg F (116 deg C).

N. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

O. Receivers: Comply with ARI 495.
1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

P. 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 (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

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:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Atofina Chemicals, Inc.
   2. DuPont Company; Fluorochemicals Div.
   3. Honeywell, Inc.; Genetron Refrigerants.
   4. INEOS Fluor Americas LLC.

C. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

D. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 2 to NPS 4 (DN 50 to DN 100) for Conventional Air-Conditioning Applications: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with soldered joints.

E. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
   1. NPS 1 (DN 25) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
   2. NPS 1 (DN 25) and Smaller: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
   3. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
   4. NPS 4 (DN 100): Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with soldered joints.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with soldered joints.

H. Safety-Relief-Valve Discharge Piping:
   1. NPS 1 (DN 25) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
   2. NPS 1 (DN 25) and Smaller: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
   3. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
   4. NPS 4 (DN 100): Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 2 to NPS 3-1/2 (DN 50 to DN 90) for Conventional Air-Conditioning Applications: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Suction Lines NPS 4 (DN 100) and Smaller for Conventional Air-Conditioning Applications: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with soldered joints.

D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

E. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

F. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

G. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

H. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 5/8 (DN 18) and Smaller: Copper, Type [ACR] [L (B)], annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 3/4 to NPS 1 (DN 20 to DN 25) and Smaller: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
3. NPS 1-1/4 (DN 32) and Smaller: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

I. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications NPS 2 to NPS 4 (DN 50 to DN 100): Schedule 40, black-steel and wrought-steel fittings with welded joints.

J. Safety-Relief-Valve Discharge Piping: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

K. Safety-Relief-Valve Discharge Piping: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

L. Safety-Relief-Valve Discharge Piping: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

M. Safety-Relief-Valve Discharge Piping: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

N. Safety-Relief-Valve Discharge Piping:
1. NPS 5/8 (DN 18) and Smaller: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 3/4 to NPS 1 (DN 20 to DN 25) and Smaller: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
3. NPS 1-1/4 (DN 32) and Smaller: Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): Copper, Type K (A) L (B), drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

3.3 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Install a full-sized, three-valve bypass around filter dryers.

E. Install solenoid valves upstream from each expansion valve and hot-gas bypass 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. Hot-gas bypass valves.
   4. Compressor.

J. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

K. Install receivers sized to accommodate pump-down charge.

L. Install flexible connectors at compressors.

3.4 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. Refer to Section 15900 "HVAC Instrumentation and Controls" and Section 15940 "Sequence of Operation" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. 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.

P. 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.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
   2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
   3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
   6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Section 15077 "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15093 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15093 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 15098 "Escutcheons for HVAC Piping."

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. 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.

F. Threaded Joints: Thread steel 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. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.6 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 15062 "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 (6 m) long.
   2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) 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 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).

D. Support multifloor vertical runs at least at each floor.

3.7 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, specialties, and receivers. 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.

3.8 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 (67 Pa). 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 (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.9 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.

END OF SECTION

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SECTION 15195

FACILITY NATURAL-GAS PIPING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipes, tubes, and fittings.
   2. Piping specialties.
   3. Piping and tubing joining materials.
   4. Valves.
   5. Pressure regulators.
   6. Service meters.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, 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.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Corrugated, stainless-steel tubing with associated components.
   3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   4. Pressure regulators. Indicate pressure ratings and capacities.
   5. Dielectric fittings.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
   1. Detail mounting, supports, and valve arrangements for service meter assembly and pressure regulator assembly.

C. Delegated-Design Submittal: For natural-gas piping and equipment 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. Detail fabrication and assembly of seismic restraints.
   2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Welding certificates.

E. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Steel Support 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.

C. 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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.8 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of natural-gas service.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 08311 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
   3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
6. Mechanical Couplings:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) Dresser Piping Specialties; Division of Dresser, Inc.
        2) Smith-Blair, Inc.
        3) Approved Equal.
    b. Steel flanges and tube with epoxy finish.
    c. Buna-nitrile seals.
    d. Steel bolts, washers, and nuts.
    e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. OmegaFlex, Inc.
    b. Parker Hannifin Corporation; Parflex Division.
    c. Titeflex.
    d. Tru-Flex Metal Hose Corp.
2. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
3. Coating: PE with flame retardant.
    a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
        1) Flame-Spread Index: 25 or less.
        2) Smoke-Developed Index: 50 or less.
4. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.

5. Striker Plates: Steel, designed to protect tubing from penetrations.
6. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
7. Operating-Pressure Rating: 5 psig (34.5 kPa).

2.2 CONTAINMENT CONDUIT

A. PVC PIPE
1. Solid Wall PVC Pipe: ASTM D2665
2. Cellular Core PVC Pipe: ASTM F891, Schedule 40.

2.3 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches (1830 mm.)

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

D. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.

3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

E. T-Pattern Strainers:
1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig (5170 kPa).

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.5 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125 psig (862 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. BrassCraft Manufacturing Company; a Masco company.
      b. Conbraco Industries, Inc.; Apollo Div.
      c. Lyall, R. W. & Company, Inc.
      d. McDonald, A. Y. Mfg. Co.
      e. Perfection Corporation; a subsidiary of American Meter Company.
   2. Body: Bronze, complying with ASTM B 584.
   3. Ball: Chrome-plated bronze.
   4. Stem: Bronze; blowout proof.
   5. Seats: Reinforced TFE; blowout proof.
   6. Packing: Threaded-body packnut design with adjustable-stem packing.
   7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   8. CWP Rating: 600 psig (4140 kPa).
   9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flowserve.
      b. Homestead Valve; a division of Olson Technologies, Inc.
      c. McDonald, A. Y. Mfg. Co.
      d. Milliken Valve Company.
      e. Mueller Co.; Gas Products Div.
      f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.
   2. Body: Cast iron, complying with ASTM A 126, Class B.
   3. Plug: Bronze or nickel-plated cast iron.
   4. Seat: Coated with thermoplastic.
   5. Stem Seal: Compatible with natural gas.
   6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   7. Operator: Square head or lug type with tamperproof feature where indicated.
   8. Pressure Class: 125 psig (862 kPa).
   9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.6 PRESSURE REGULATORS

A. General Requirements:
   1. Single stage and suitable for natural gas.
   2. Steel jacket and corrosion-resistant components.
   3. Elevation compensator.
   4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Provided and set by Duke Energy.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Canadian Meter Company Inc.
      b. Eaton Corporation; Controls Div.
      c. Harper Wyman Co.
      d. Maxitrol Company.
      e. SCP, Inc.
   2. Body and Diaphragm Case: Die-cast aluminum.
   3. Springs: Zinc-plated steel; interchangeable.
   4. Diaphragm Plate: Zinc-plated steel.
   5. Seat Disc: Nitrile rubber.
   6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
   7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
   8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
   9. Maximum Inlet Pressure: 1 psig (6.9 kPa).

2.7 SERVICE METERS

A. Provided and set by Duke Energy.

2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
   1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available 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. Jomar International Ltd.
e. Matco-Norca, Inc.
f. McDonald, A. Y. Mfg. Co.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. Wilkins; a Zurn company.

2. Description:
   a. Standard: ASSE 1079.
   b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F.
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.9 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. By Duke Energy.

B. Containment Conduit

1. Install and backfill 4 inch conduit (with a smooth wall interior) at a depth of at least 18 inches of cover. Temporarily seal both ends of the conduit. Leave both ends of conduit uncovered. Finish the backfilling and grading. Backfill shall be sand or the soil free of coarse material such as rocks. Backfill material shall be located in the vicinity of the excavation but no closer than 2 feet of the trench.
2. Conduit length shall be limited to 100 feet. A series of conduits are required for longer services or where more turns are necessary. Intermediate pull excavations (4 feet x 2 feet) are required every 100 feet for longer services. One 90 degree (minimum bend radius = 3 feet) change in direction is permitted for 1-1/4 inch and smaller services. Turns are not permitted on conduit for 2 inch services.
3. Install buried gas line caution tape at 6 inches above the conduit. The tape must be bright yellow in color and a minimum of 2 inches wide with black 1 inch lettering. Leave a minimum of 2 feet of caution tape exposed on each end of the conduit. Caution tape must be visible on each end of the conduit. An example of buried gas main caution tape can be seen below.
4. Excavation area at the foundation wall shall be 4 feet x 3 feet. Bottom of excavation shall be within 2 feet of final grade to provide proper service riser support. Mark final grade on the foundation wall to aid in the proper placement of the service riser. End of the conduit shall be located 4 feet from the foundation wall.
5. Excavation area at the street end of the gas service shall be 4 feet x 2 feet. Edge of excavation shall be located no more than 2 feet from gas supply location.
6. Customer shall provide a pull string through conduit. Pull string shall have a minimum tensile strength of 100 pounds.

EXHIBIT B – SAMPLE BURIED GAS LINE CAUTION TAPE

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping 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. Locate valves for easy access.

F. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Verify final equipment locations for roughing-in.

J. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

K .Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

L. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

M. Prohibited Locations:

1. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
2. Do not install natural-gas piping in solid walls or partitions.

N. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

O. Connect branch piping from top or side of horizontal piping.

P. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

Q. Do not use natural-gas piping as grounding electrode.

R. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15093 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15093 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 15098 "Escutcheons for HVAC Piping."

3.5 SERVICE-METER ASSEMBLY INSTALLATION

A. By Duke Energy.

3.6 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
   5. 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.

D. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

E. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.8 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 15074 "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Comply with requirements for pipe hangers and supports specified in Section 15062 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
   2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
   3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
   4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).

D. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
   1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
   2. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
   3. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

3.9 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements (Duke Energy’s Gas Installers Manual).

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

A. Comply with requirements in Section 15077 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.11 PAINTING

A. Comply with requirements in Section 09910 "Painting" for painting interior natural-gas piping.

B. Paint exposed, interior metal piping, valves, service regulators, and meter bars, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Interior latex matching topcoat.
      c. Topcoat: Interior latex (flat).
      d. Color: Yellow.

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.14 OUTDOOR PIPING SCHEDULE

A. By Duke Energy.

B. Containment Conduit: 4" PVC pipe with PVC fittings and pull string. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:
   1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
   2. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 5 PSIG (34.5 kPa)

A. Aboveground, distribution piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

3.17 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.

B. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be the following:
   1. Cast-iron, lubricated plug valve.

C. Valves in branch piping for single appliance shall be[one of] the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION

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SECTION 15412

EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Combination units.
   2. Water-tempering equipment.

1.3 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.

D. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Flushing-Fluid Solution: Separate lot and equal to at least 200 percent of amount of solution installed for each self-contained unit.

1.8 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. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

D. Regulatory Requirements: Comply with requirements in ICC/ANSI A117.1, "Accessible and Usable Buildings and Facilities"for plumbing fixtures for people with disabilities.

PART 2 - PRODUCTS

2.1 COMBINATION UNITS

A. Accessible, Plumbed Emergency Shower with Eye/Face Wash Combination Units:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or equal product by one of the following:
      a. Acorn Safety; a division of Acorn Engineering Company.
      b. Bradley Corporation.
      c. Encon Safety Products.
      d. Guardian Equipment Co.
      e. Haws Corporation.
      f. Sellstrom Manufacturing Company.
      g. Speakman Company.
      h. WaterSaver Faucet Co.
   2. Piping: See Plumbing Fixture schedule
   3. Shower: See Plumbing Fixture schedule
   4. Eye/Face Wash Unit: See Plumbing Fixture schedule

2.2 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Acorn Safety; a division of Acorn Engineering Company.
      b. Armstrong International, Inc.
      c. Bradley Corporation.
      d. Encon Safety Products.
      e. Guardian Equipment Co.
      f. Haws Corporation.
      g. Lawler Manufacturing Co., Inc.
      h. Leonard Valve Company.
      i. Powers; a division of Watts Water Technologies, Inc.
      j. Speakman Company.
   2. Description: Factory-fabricated equipment with thermostatic mixing valve.
      a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
      b. Supply Connections: For hot and cold water.

2.3 SOURCE QUALITY CONTROL

A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

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

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Division 15 Section "General-Duty Valves for Plumbing Piping."
   1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
   2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping. Comply with requirements for steam and condensate piping specified in Division 15 Section "Steam and Condensate Piping."

F. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Division 15 Section "Domestic Water Piping."

G. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Division 15 Section "Meters and Gages for Plumbing Piping."

H. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Division 15 Section "Sanitary Waste and Vent Piping."

I. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Division 15 Section "Sanitary Waste and Vent Piping."

J. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Division 15 Section "Escutcheons for Plumbing Piping."

K. Fill self-contained fixtures with flushing fluid.

3.3 CONNECTIONS

A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Division 15 Section "Domestic Water Piping."

B. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Division 15 Section "Sanitary Waste and Vent Piping."

C. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.

D. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Division 15 Section "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection.
   2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

+ + END OF SECTION + +

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SECTION 15416

COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Water closets.
   2. Flushometer valves.
   3. Toilet seats.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
   1. Flushometer-Valve Repair Kits: No fewer than four (4) of each type.

PART 2 - PRODUCTS

A. See Plumbing Schedule on the Plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.

B. Examine walls and floors for suitable conditions where water closets will be installed.

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

3.2 INSTALLATION

A. Water-Closet Installation:
   1. Install level and plumb according to roughing-in drawings.
   2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
   3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:
   1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
   2. Use carrier supports with waste-fitting assembly and seal.
   3. Install floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
   4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:
   1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
   2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
   3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
   4. Install actuators in locations that are easy for people with disabilities to reach.
   5. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:
   1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.

2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Division 15 Section "Escutcheons for Plumbing Piping."

F. Joint Sealing:
1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Division 7 Section "Joint Sealants."

3.3 CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Division 15 Section "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Division 15 Section "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

+ + END OF SECTION + +

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SECTION 15421

COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Lavatories.
   2. Faucets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.
   1. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
      a. Servicing and adjustments of automatic faucets.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

A. See Plumbing Schedule on the Plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.

B. Examine counters and walls for suitable conditions where lavatories will be installed.

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

3.2 INSTALLATION

A. Install lavatories level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Division 15 Section "Escutcheons for Plumbing Piping."

E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Division 7 Section "Joint Sealants."

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Division 15 Section "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Division 15 Section "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Division 15 Section "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

+ + END OF SECTION + +

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SECTION 15422

COMMERCIAL SINKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Service basins.
   2. Utility sinks.
   3. Sink faucets.
   4. Supply fittings.
   5. Waste fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.
   2. Include rated capacities, operating characteristics and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sinks to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Faucet Washers and O-Rings: 5 percent of each type and size installed.
   2. Faucet Cartridges and O-Rings: 5 percent of each type and size installed.

PART 2 - PRODUCTS

A. See Plumbing Schedule on the Plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A, Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.

B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.

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

3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-hung sinks.

C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.

D. Set floor-mounted sinks in leveling bed of cement grout.

E. Install water-supply piping with stop on each supply to each sink faucet.
   1. Exception: Use ball, gate, or globe valves if supply stops are not specified with sink. Comply with valve requirements specified in Division 15 Section "General-Duty Valves for Plumbing Piping."
   2. Install stops in locations where they can be easily reached for operation.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Division 15 Section "Escutcheons for Plumbing Piping."

G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Division 7 Section "Joint Sealants."

H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Division 22 Section "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Division 15 Section "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Division 15 Section "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

+ + END OF SECTION + +

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SECTION 15427

PRESSURE WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pressure water coolers and related components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pressure water cooler.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filter Cartridges: No fewer than 5 of each.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Pressure Water Coolers Wall mounted, wheelchair accessible.
   1. Manufacturers: See Plumbing Schedule on the Plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.

B. Set freestanding pressure water coolers on floor.

C. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

D. Install mounting frames, affixed to building construction, and attach recessed, pressure water coolers to mounting frames.

E. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 15 Section "General-Duty Valves for Plumbing Piping."

F. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Division 15 Section "Escutcheons for Plumbing Piping."

H. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Division 7 Section "Joint Sealants."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Division 15 Section "Domestic Water Piping."

C. Install ball valve on water supply to each fixture. Install valve upstream from filter for water cooler. Comply with valve requirements specified in Division 15 Section "General-Duty Valves for Plumbing Piping."

D. Comply with soil and waste piping requirements specified in Division 15 Section "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

+ + END OF SECTION + +

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SECTION 15483

COMPRESSED AIR SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified, and required to furnish and install compressed air system complete with accessories.

B. Related Sections:
   1. Division 1, General Requirements.
   2. Section 09910, Painting.
   3. Section 15121, Wall Pipes, Floor Pipes, and Pipe Sleeves.
   4. Division 15, Mechanical.
   5. Division 16, Electrical.

1.2 QUALITY ASSURANCE

A. Installer's Qualifications:
   1. Engage a single installer for the compressed air system with undivided responsibility for performance and other requirements with experience in the installation of the types of materials required; and who agrees to employ only tradesmen with specific skill and experience in this type of Work. Submit name and qualifications to ENGINEER.

B. Requirements of Regulatory Agencies: Comply with applicable provisions and recommendations of the following except as otherwise shown or specified.
   1. Local and State Building Codes and Ordinances.
   2. Underwriters Laboratories, Incorporated.
   3. National Fire Protection Association.
   4. National Electric Code.
   5. National Electrical Manufacturers' Association.
   6. Institute of Electrical and Electronic Engineers.
   7. American National Standards Institute.
   8. American Society of Mechanical Engineers.
   9. Permits: CONTRACTOR shall obtain and pay for all required permits, fees and inspections.

C. Reference Standards: Comply with applicable provisions and recommendations of the following except as otherwise shown or specified:
   1. NFPA 99, Standard for Health Care Facilities.
   2. NFPA 70, National Electric Code.
   3. NFPA 72, National Fire Alarm Code.

1.3 SUBMITTALS

A. Shop Drawings:
Submit the following for approval:
1. 1/4-inch scale piping and equipment layouts, dimensioned to show length of piping runs, pipe sizes, support spacing and expansion provisions.
2. Details of installation, including piping supports.
3. Manufacturer's literature, illustrations, specifications and engineering data.
4. Flexible connections.
5. Other technical data related to the specified material and equipment as requested by ENGINEER.
6. Submit pipe schedule with laminate construction, sizes, thickness, vacuum pressure, weight per foot pressure, spans, joint type and flange data.
7. Gasket material.
8. Deviations from Contract Documents.

B. Record Drawings:
1. During progress of the Work keep an up to date set of the Drawings showing field and Shop Drawing modifications. Immediately upon completion of piping work, submit CAD drawings showing the actual in-place installation of all piping and equipment installed under this Section, at a scale satisfactory to the OWNER. The Drawings shall show all piping on plans and in sections, with all reference dimensions and elevations required for complete “record” drawings of the piping systems. Two paper prints shall also be furnished in addition to the CAD drawings. The CAD drawings shall be furnished no later than 30 days after completion of the Contract and prior to final payment.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery of Materials:
1. Compressor assembly shall come completely assembled and protected in wooden crates or on skids.
2. Suction and discharge ports shall be protected against entry of foreign object.
3. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to prevent delay of the Work.
4. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. CONTRACTOR shall notify ENGINEER if any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition, in accordance with manufacturer’s instructions.

B. Storage of Materials:

1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
2. Store all equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.

1.5 JOB CONDITIONS

A. Protection: Properly plug or cap the open ends of all piping at the end of each day's work or other stopping point through construction. Equipment and piping shall be tightly covered and protected against dirt, water and chemical, or mechanical injury.

1.6 GENERAL REQUIREMENTS

A. The Drawings accompanying these Specifications show the general arrangement and extent of work to be done, but the exact location and arrangement of all parts shall be determined as the work progresses, to conform in the best possible manner with its surroundings; the exact location of all parts of the work must be governed by the general building plans and the actual building conditions.

B. The Drawings are intended as an indication of the arrangement of equipment, piping, valves, and system components, and are as nearly correct as can be determined in advance of the actual construction of the Work. It must however, be understood that the piping, equipment and system components found to interfere with the construction of the building, plumbing apparatus and piping, electrical wiring or other obstructions, etc., must be changed in location to clear such obstructions, without additional charge.

C. The connections indicated to the various units are particularly intended as an indication only. The actual connections at the time of installation to be made and arranged as to fully and best suit the requirements of each particular case, adequately provide for expansion and perfect circulation and minimize the amount of space required for the same.

D. The Drawings show the general arrangement of all systems. Should local conditions necessitate rearrangement of one or more of the systems, or if piping or ductwork can be run to better advantage and at the same time accomplish as good or better results, CONTRACTOR, before proceeding with the Work, shall prepare and submit complete drawings showing all details of the proposed rearrangement for written approval.

E. The Drawings preclude indicating thereon, all offsets, fittings, accessories and details, which may be required. CONTRACTOR shall carefully examine all of

the General Construction, Electrical, Mechanical, Structural and other Drawings and the respective Specifications for conditions which may affect the installation of his work, and shall arrange his work accordingly, furnishing all required items to meet such conditions which are not specified as work "by others", to complete the systems to the true extent of the Drawings and Specifications.

1.7 WARRANTY

A. General Warranty:
   1. The guaranty period shall be set forth in specification Section 00710, “General Conditions”. In the event that the manufacturers guarantee period exceeds that as stated in the General Conditions, the manufacturers guarantee period will stay in effect and shall not be replaced by the previously stated.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Copper Tube:
   1. Pipe:
      a. Reference: ANSI H23.1.
      b. Type: “K”.
      c. Temper: Hard-drawn.
   2. Fittings:
      a. Reference: ANSI B16.22.
   3. Joints:
      a. Brazed.
         1) Reference: ANSI/AWS-A5.8 Filler Metals for Brazing.
            a) Brazing Filler Metal: BCup-4, BCup-5.
   4. Unions:
      a. Reference: FS WW-U-516.
      b. Material: Bronze.
      c. Rating: 250 pound WOG

B. Bronze Body Ball Valves:
   1. Manufacturer: Provide products of one of the following:
      a. Nibco, Incorporated, Fig. No. S-585-70.
      b. Lunkenheimer Company, Fig. No. 707-XLT.
      c. Watts Regulator Company, No. B-6001.
      d. Or equal.
   2. Type: Non-blowout stem, adjustable packing gland, quarter turn, full port ball valve for air service and vacuum service as required. Valves shall be cleaned and degreased.
   3. Materials:

a. Body: Bronze.
b. Ball: Bronze.
c. Seats and Seals: Reinforced Teflon.

4. Rating: 400 psi WOG minimum.
5. End Connection: Threaded.

C. Bronze Body Pressure Regulating Valves:
1. Manufacturer: Provide products of one of the following:
a. Cashco Division, Riley Company, Type "D".
b. Or equal.
2. Type: Spring and diaphragm, single seat.
3. Materials:
a. Body: Bronze.
b. Trim: Stainless steel.
c. Spring: Stainless steel.
d. Valve seat: Metal.
e. Diaphragm: Neoprene or Buna-N.
4. Maximum Inlet Pressure: 400 psig.
5. Outlet Pressure: Adjustable between 10 and 40 psig.

D. Pressure Gauges:
1. Provide gauges per Specification 13420 Primary Sensors and Field Instruments.
2. Range: 0 to 150 psig.

E. Dielectric Unions:
a. Manufacturer: Provide products of one of the following:
1) Watts Regulator Company.
2) EPCO Sales Incorporated.
3) Or equal.
b. Reference: ANSI B16.39.
c. Type: Union.

F. Pipe Drains:
1. Type: Bronze compression-type globe valve with hose end.
2. Rating: 150 pound SWP.
3. Size: 3/4 inch.

G. Relief Valves:
1. Manufacturer: Provide products of one of the following:
a. A.W. Cash Valve Manufacturing Corporation.
b. Watts Regulator Company.
c. Or equal.
2. Type: ASME Pressure relief valve only.
3. Materials: Bronze body, silicone seat disc, stainless steel springs, brass test lever.

4. Valve set to relieve as shown on Drawings.

H. Pipe Labels:
1. Type: Self-adhering, temperature resistant, waterproof, corrosion resistant.
2. Marker size, marker color, legend size, and legend color shall conform to ANSI A13.1.

2.2 COMPRESSED AIR SYSTEM

A. Manufacturer: Provide products of one of the following:
1. Ingersoll Rand Air Solutions, Model UP6-30-125.
2. Or equal.

B. Type: Rotary screw air compressor with food grade oil, tank mounted with 120 gallon receiver, with microprocessor controls.

C. Capacity of compressor shall be no less than 100 SCFM at 50 psig requiring no more than 30 horsepower with a maximum operating pressure of 125 psig. All interconnecting package wiring external to control panel shall be in accordance with Division 16.

D. Power supply shall be 460 Volt, 3 Phase, 60 Hz.

E. Microprocessor Controls:
1. Provide controls in tank mounted sound enclosure with noise levels at or below 69 dBA. Shall include automatic belt tensioning system and air end bearings to protect against over tension, under tension, and slippage.

F. Accessories:
1. Pre Filters:
a. Type A, Pre Filter 1
1) Provide one pre filter configured as shown on Drawings.
2) Manufacturer:
a) Ingersoll Rand Air Solutions, Model F212IG.
b) Or equal.
b. Type B, Pre Filter 2
1) Provide one pre filter configured as shown on Drawings.
2) Manufacturer:
a) Ingersoll Rand Air Solutions, Model F212IH.
b) Or equal.
2. Post Filters:
a. Type A
1) Provide one post filter as shown on Drawings.
2) Manufacturer:
a) Ingersoll Rand Air Solutions, Model F212ID.
b) Or equal.

3. Desiccant Dryer
    a. Provide one desiccant dryer configured as shown on Drawings. Dryer shall be regenerative and have noise levels less than 75 dB. Dryer shall be refrigerant-free and be provided with a NEMA4/IP-66 enclosure. Dryer shall provide standard ISO Class 2 dewpoint performance.
    b. Manufacturer:
        1) Ingersoll Rand Air Solutions, Model D221IM, 115VAC.
        2) Or equal.
4. Air Hose
    a. Style: Heavy duty multi purpose rubber air hose for use in supplying air to the GAC delivery trucks and GAC pressure vessels.
    b. Hose Size: 1-inch as scheduled below.
    c. Pressure Rating: Maximum 125 psig.
    d. End Connections: Contractor shall coordinate end connections with Drawings and selected manufacturers.
    e. Provide the following hoses:
        a. 1-inch air hose with end connections coordinated with Drawings and selected manufacturers: Four 50 foot long hoses, one located at each compressed air station.
    f. Provide a hose rack for each air station as shown on DRAWINGS.
5. Drains
    a. Contractor shall combine all air compressor drains and pipe to single floor drain no greater than 3 inches from floor. Floor drain location shown on DRAWINGS.
6. Shelves
    a. Provide each air station with one 24” wide by 12” deep Type 304 stainless steel wall shelf as shown on DRAWINGS.

G. Spare Parts:
    1. Provide a one year’s supply of filters, lubricants, and food grade oil.

PART 3 – EXECUTION

3.1 INSTALLATION

A. General:
    1. Install all items as shown, specified, and as recommended by the manufacturer.
    2. Request instructions from ENGINEER when there is a conflict between the manufacturer's recommendations and the Contract Documents.
    3. Present conflicts between piping systems and/or equipment and/or structures to ENGINEER who will determine corrective measures to be taken.
    4. Do not modify structures to facilitate installation of piping unless specifically approved by ENGINEER.

5. Installation to conform to requirements of all local and state codes.

B. Installation of piping shall be in accordance with Section 15052, Exposed Piping Installation.

C. All piping shall be pitched to facilitate draining. Drain valves shall be provided at system low points.

D. Unions shall be provided for all screwed piping at connections to equipment and at convenient locations to permit disassembly of piping.

E. All connections between ferrous and non-ferrous piping materials shall be made with dielectric couplings.

F. Wherever changes in sizes of piping occur, changes shall be made with reducing fittings. The use of bushings is not permitted unless otherwise shown.

G. All exposed pipes shall be identified with pipe labels and the direction of flow indicated. Labels may be omitted from piping where the use is obvious, due to its connection to fixtures and where the appearance would be objectionable in finished rooms; as approved by the ENGINEER. Identification labels shall be placed as follows:
   1. Near each valve and branch connection.
   2. Wherever piping emerges or disappears from view, when viewed from the floor of the room in which it is installed.
   3. At not more than 50 foot intervals.

H. Manufacturer's representatives shall check and approve the installation of the compressed air system before operation. They shall test operate each system and verify that the compressed air conforms to requirements, and instruct plant personnel on care and maintenance of the equipment. They shall revisit the jobsite as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

3.2 FIELD QUALITY CONTROL

A. Field Tests
   1. Pressure tests all systems.
   2. Fill all systems and fully test all equipment, valves and piping in operation.
   3. Check for excessive vibration while all systems are operating.
   4. Installed systems and components will not be released to OWNER unless all systems have been tested and approved by the ENGINEER.

B. Inspection:
   1. Examine areas to receive equipment, piping, valves, and accessories for:
      a. Defects that adversely affect execution and quality of Work.

b. Deviations beyond allowable tolerances for equipment, piping, valves, and accessories.
c. Start work only when conditions are satisfactory.

2. The ENGINEER reserves the right to reject and/or authorize replacement of equipment, piping, valves, and accessories found to be defective, blistered, cracked and/or deviated from allowable tolerances as described above.

3.3 ADJUSTING & CLEANING

A. Adjusting:
1. Adjust all controls for proper settings.
2. While system is operable, balance all equipment, valves and sensors to achieve design conditions.

B. Cleaning:
1. Clean dirt, marks, and remove other debris from compressor assembly.
2. Thoroughly clean all piping, fittings, valves, equipment, and accessories prior to installation.
3. Remove all dirt, rust, dust and foreign materials. from piping and equipment in preparation for painting.
4. Remove and dispose of all debris and waste from the site resulting from installation.

3.4 MANUFACTURER'S SERVICES

A. A factory-trained representative shall be provided for start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of three visits, minimum eight hours on-site for each visit, to the site. The first visit shall be for checking the completed installation and start-up of the system. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the equipment conforms to requirements. Manufacturer's representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory. The second visit shall provide operations and maintenance personnel training services.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

3.5 MATERIAL SCHEDULES

A. Piping:
1. Use types of pipe and fittings as specified below unless otherwise specified or shown.

2. All compressed air piping 2-inches and smaller run within the interior and exterior of the building shall be soft-annealed copper type “K” copper tubing with brazed joints.
3. Use "wrought copper" fittings for copper tubing.

3.6 PAINTING

A. All piping/equipment and accessories shall be painted in accordance with Specification Section 09910, Painting.

+ + END OF SECTION +

SECTION 15485

ELECTRIC WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Commercial, light-duty, electric, water heaters.
   2. Water heater accessories.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: See Structural plans.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:
   1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For commercial domestic-water heaters, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of commercial and tankless, electric, domestic-water heater, from manufacturer.

C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.7 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. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including storage tank and supports.
      b. Faulty operation of controls.

c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.
   a. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:
      1) Storage Tank: Five years.
      2) Controls and Other Components: Three years.
   b. Electric, Tankless, Domestic-Water Heaters: Five year(s).
   c. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 ELECTRIC, TANKLESS, domestic-WATER HEATERS

A. Flow-Control, Electric, Tankless, Domestic-Water Heaters:
   1. Manufacturers: See Water Heater schedule.
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or approved equal product by one of the following:
      a. Bosch Water Heating.
      b. Chronomite Laboratories, Inc.
      c. Eemax, Inc.
      d. Stiebel Eltron, Inc.
   3. Standard: UL 499 for electric, tankless, (domestic-water heater) heating appliance.
   4. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
      a. Connections: ASME B1.20.1 pipe thread.
      b. Pressure Rating: 150 psig (1035 kPa).
      c. Heating Element: Resistance heating system.
      d. Temperature Control: Flow-control fitting.
      e. Safety Control: High-temperature-limit cutoff device or system.
      f. Jacket: Aluminum or steel with enameled finish or plastic.
   5. Support: Bracket for wall mounting.
   6. Capacity and Characteristics: See Water Heater schedule.

2.2 WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:
   1. Manufacturers: See Expansion Tank schedule.
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or approved equal product by one of the following:
      a. AMTROL Inc.
      b. Flexcon Industries.
      c. Honeywell International Inc.
      d. Pentair Pump Group (The); Myers.

e. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
f. State Industries.
g. Taco, Inc.

3. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
4. Construction:
   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.
5. Capacity and Characteristics: See Expansion Tank schedule.

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1.

D. Heat-Trap Fittings: ASHRAE 90.2.

E. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig- (172.5-kPa-) maximum outlet pressure unless otherwise indicated.

F. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

G. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.

H. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

I. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

J. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Division 1 Section "Quality Requirements" for retesting and reinspecting requirements and Division 1 Section "Execution Requirements" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Division 3 Section "Cast-in-Place Concrete."
   1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
   2. Maintain manufacturer's recommended clearances.
   3. Arrange units so controls and devices that require servicing are accessible.
   4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   7. Install anchor bolts to elevations required for proper attachment to supported equipment.
   8. Anchor domestic-water heaters to substrate.

B. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters[at least 18 inches (457 mm) above floor] on wall bracket.
   1. Maintain manufacturer's recommended clearances.
   2. Arrange units so controls and devices that require servicing are accessible.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.
   5. Anchor domestic-water heaters to substrate.

C. Install electric, domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
   1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Division 15 Section "General-Duty Valves for Plumbing Piping."

D. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

E. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

F. Install combination temperature-and-pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

G. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Division 15 Section "Domestic Water Piping Specialties."

H. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Division 15 Section "Meters and Gages for Plumbing Piping."

I. Install thermometers on inlet and outlet piping of residential, solar, electric, domestic-water heaters. Comply with requirements for thermometers specified in Division 15 Section "Meters and Gages for Plumbing Piping."

J. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.

K. Fill electric, domestic-water heaters with water.

L. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Division 15 Section "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Division 15 Section "Identification for Plumbing Piping and Equipment."

3.4 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.
   2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Division 1 Section "Quality Requirements" for retesting and reinspecting requirements and Division 1 Section "Execution Requirements" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial and tankless, electric, domestic-water heaters.

+ + END OF SECTION + +

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SECTION 15735

SELF-CONTAINED AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes packaged, air-cooled air-conditioning units with refrigerant compressors and controls intended for indoor installations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For self-contained air conditioners to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: Two sets of filters for each unit.

2. Fan Belts: One set of belts for each unit.
3. Gaskets: One set for each access door.
4. Fuses: One set for each air-handling unit.

1.7 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. ARI Compliance:
1. Applicable requirements in ARI 210/240.
2. Applicable requirements in ARI 340/360.
3. Applicable requirements in ARI 390.

C. ASHRAE Compliance:
1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 03300 "Cast-in-Place Concrete."

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of self-contained air conditioners that fail in materials or workmanship within specified warranty period.
1. Warranty Period:
a. For Compressor: Five years from date of Substantial Completion.
b. For Parts: Five years from date of Substantial Completion.
c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bard Manufacturing Company.
   2. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
   3. McQuay International.
   4. Trane Inc.

2.2 PACKAGED UNITS

A. Description: Factory assembled, wired, and tested; and fully charged with refrigerant and oil.

B. Configuration: Vertical, floor mounted; horizontal discharge and return.

C. Disconnect Switch: Factory mounted in control panel.

2.3 Cabinet

A. Frame and Panels: Structural-steel frame with galvanized-steel panels and access doors or panels.
   1. Exterior-Surface Finish: Factory painted in color selected by Architect.
   2. Interior-Surface Finish: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Insulation: 1-inch- (25-mm-) thick, glass-fiber duct liner complying with ASTM C 1091 and having a microbial coating on cabinet interior and control panel. 1/2-inch- (13-mm-) thick liner is acceptable for units smaller than 15 tons (50 kW).

C. Return-Air Opening: Front in the same plane as discharge opening.

D. Corrosion-Resistant Treatment: Phenolic coating on unit interior and exterior.

2.4 Supply-air Fan

A. Fan Material: Galvanized steel.

B. Configuration: Double-width, double-inlet, airfoil centrifugal fan; statically and dynamically balanced. Horizontal discharge with flexible discharge collar.

C. Drive: Belt, with fan mounted on permanently lubricated bearings.

D. Fan Sheaves: Variable pitch, dynamically balanced, bored to fit shafts, and keyed for initial startup.

E. Motor Sheave: Variable and adjustable pitch, dynamically balanced, and selected to achieve specified rpm when set at midposition.

F. Belt Rating: As recommended by manufacturer or a minimum of one and one-half times nameplate rating of motor.

G. Bearings: Grease lubricated with grease lines extended to exterior of unit with L-50 life at 200,000 hours.

H. Comply with NEMA MG 1designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 15058 "Common Motor Requirements for HVAC Equipment."
   1. Special Motor Features: Premium efficiency, as defined in Section 15058 "Common Motor Requirements for HVAC Equipment."
   2. <Insert unique motor characteristics>.

I. Isolation: Mount fan and motor on common subbase and mount assembly on spring isolators with minimum static deflection of 1 inch (25 mm).

J. Outdoor-Air-Intake Accessories:
   1. Motorized Outdoor-Air Damper: Motorized, two-position blade damper allowing induction of up to 25 percent outdoor air; with spring-return, low-voltage damper motor.
   2. Air-Side Economizer: Damper assembly allowing induction of up to 100 percent outdoor air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.

2.5 REFRIGERATION SYSTEM

A. Compressor: Scroll type, hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.

B. Refrigerant Coils (Indoor and Outdoor for Air-Cooled Units): Seamless copper tubes expanded into aluminum fins.
   1. Corrosion-Resistant Treatment: Phenolic coating applied with multiple dips and baked.
   2. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve with adjustable superheat, filter dryer, sight glass, high-pressure relief valve, and charging valves.
   3. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1.
   4. Refrigerant: R-410A.
   5. Expansion valve with replaceable thermostatic element.
   6. Refrigerant dryer.
   7. High-pressure switch.

8. Low-pressure switch.
9. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
10. Low ambient control down to OF.
11. Brass service valves installed in discharge and liquid lines.

2.6 Heating Coil

A. 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.

2.7 CONTROLS

A. Control equipment is specified in Section 15900 "HVAC Instrumentation and Controls".

B. Control Package: Factory wired, including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay.

C. Time-Delay Relay: Five-minute delay to prevent compressor cycling.

D. Adjustable Thermostat: Remote to control the following:
1. Supply fan.
2. Compressor.
3. Condenser.
4. Electric heater.

E. System Selector Switch: Off-heat-auto-cool.

F. Fan Control Switch: Auto-on.

G. Time Clock: Cycle unit on and off.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Anchor units to structure.

C. Install seismic restraints.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. Duct Connections: Duct installation requirements are specified in Section 15815 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to self-contained air conditioners with flexible duct connectors. Flexible duct connectors are specified in Section 15820 "Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. 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.

C. Tests and Inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation, and inspect for refrigerant leaks.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

+ + END OF SECTION + +

SECTION 15738

SPLIT-SYSTEM AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: Two sets for each air-handling unit.
   2. Gaskets: One set for each access door.
   3. Fan Belts: One set for each air-handling unit fan.

1.7 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. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 03300 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period:
      a. For Compressor: Five years from date of Substantial Completion.
      b. For Parts: Five years from date of Substantial Completion.
      c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
   2. Daikin.
   3. Lennox International Inc.
   4. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
   5. Trane; a business of American Standard companies.
   6. YORK; a Johnson Controls company.

2.2 INDOOR UNITS (5 TONS (18 kW) 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 210/240.
   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.
      c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
   7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
   8. Filters: Permanent, cleanable.
   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 (50 mm) deep.
      b. Double-wall, [galvanized] [stainless]-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
   1) Minimum Connection Size: NPS 1 (DN 25).
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. Ceiling Cassette Unit:
1. General: The ceiling cassette fan coil unit, operable with R410A refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity equipped with an air panel grille. It shall be available from 12,000 Btu/h to 36,000 Btu/h. It shall be a four-way air distribution type, ivory white, impact resistant, and washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°. Computerized PID control shall be used to maintain room temperature within 1°F. Equipped with a programmed drying mechanism that dehumidifies while inhibiting changes in room temperature when used with the remote control units. The indoor units sound pressure shall range from 28 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
2. Indoor Unit:
   a. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
   b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
   c. Both refrigerant lines shall be insulated from the outdoor unit.
   d. The 4-way supply air flow can be field modified to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.
   e. Return air shall be through the concentric panel, which includes a resin net mold resistant filter.
   f. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 21” of lift.
   g. The indoor units shall be equipped with a return air thermistor.
3. Cabinet:
   a. Cabinet: Enameled steel with removable panels on front and ends in color to match ceiling, and discharge drain pans with drain connection.
   b. The cabinet shall be space saving and shall be located into the ceiling.
   c. Three auto-swing positions shall be available to choose, which include standard, draft prevention and ceiling stain prevention.
   d. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
   e. Fresh air intake shall be possible by way of the optional fresh intake kit.

f. A branch duct knockout shall exist for branch ducting supply air.
g. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
h. Optional high efficiency air filters are available for each model unit.

4. Fan:
   a. The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with high and low fan speeds available.
   b. The air flow rate shall be available in high and low settings.
   c. The fan motor shall be thermally protected.
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.
   c. Enclosure Type: Totally enclosed, fan cooled.
   d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
   e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
   f. Mount unit-mounted disconnect switches on exterior of unit.
6. Refrigerant Coil:
   a. Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
   b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
   c. The coil shall be a 2 row cross fin copper evaporator coil with 17 FPI design completely factory tested.
   d. The refrigerant connections shall be flare connections.
   e. A condensate pan shall be located under the coil.
   f. A condensate pump with a 21 inch lift shall be located below the coil in the condensate pan with a built in safety alarm.
   g. A thermistor will be located on the liquid and gas line.
7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
8. 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 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 1 inch (25 mm) deep.
   b. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
      1) Minimum Connection Size: NPS 1 1/4 (DN 30).
   c. Pan-Top Surface Coating: Asphaltic waterproofing compound.

9. Air Filtration Section:
    a. General Requirements for Air Filtration Section:
        1) Comply with NFPA 90A.
        2) Minimum Arrestance: According to ASHRAE 52.1 and ASHRAE 52.2.
        3) The return air shall be filtered by means of a washable long-life filter with mildew proof resin.
        4) 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.
10. Electrical:
    a. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
    b. Transmission (control) wiring between the indoor and remote controller shall be a maximum distance of 1,640 feet.
11. Control:
    a. The unit shall have controls provided to perform input functions necessary to operate the system.
    b. The unit shall be compatible with interfacing with connection to LonWorks networks or interfacing with connection to BMS system.
12. Accessories:
    a. Fresh air intake and supply air duct connections.
    b. Remote “in-room” sensor kit.
        1) A wall mounted, hard wired remote sensor kit is required for ceiling-embedded type fan coils, The sensor for detecting the temperature can be placed away from the indoor unit (branch wiring is included in the kit.).

2.3 INDOOR UNITS (6 TONS (21 kW) OR MORE)

A Floor-Mounted, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
    a. Discharge and Return Grille: Steel with surface-mounted frame].
    b. Insulation: Faced, glass-fiber duct liner.
2. 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 (50 mm) deep.
    b. Double-wall, [galvanized] [stainless]-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on [one end] [both ends] of pan.
   1) Minimum Connection Size: NPS 1 (DN 25).
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.

3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
4. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; with a two-position control valve.
5. 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.
6. Fan: Direct drive, centrifugal, with power-induced outside air.
7. 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.
   c. Enclosure Type: Totally enclosed, fan cooled.
   d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
   e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
   f. Mount unit-mounted disconnect switches on exterior of unit.
8. Air Filtration Section:
   a. General Requirements for Air Filtration Section:
      1) Comply with NFPA 90A.
      2) Minimum Arrestance: According to ASHRAE 52.1 and a 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. Extended-Surface, Disposable Panel Filters:
      1) Factory-fabricated, dry, extended-surface type.
      2) Arrestance according to ASHRAE 52.1: >90%.
      3) Merv according to ASHRAE 52.2: 8.
      4) Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent and held by self-supporting wire grid.
      5) Media-Grid Frame: Nonflammable cardboard.
      6) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.4 OUTDOOR UNITS (5 TONS (18 kW) OR LESS)

A. Air-Cooled, Compressor-Condenser Components:
   1. Casing: Steel, finished with baked enamel in color selected by Architect, 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.
   2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
      a. Compressor Type: Scroll.
      b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
      c. Refrigerant Charge: R-410A.
      d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 210/240.
   3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
   4. Fan: Aluminum-propeller type, directly connected to motor.
   5. Motor: Permanently lubricated, with integral thermal-overload protection.
   6. Low Ambient Kit: Permits operation down to 0 deg F.
   7. Mounting Base: Polyethylene.

2.5 OUTDOOR UNITS (6 TONS (21 kW) OR MORE)

A. Air-Cooled, Compressor-Condenser Components:
   1. Casing: Steel, finished with baked enamel in color selected by Architect, 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.
   2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
      a. Compressor Type: Scroll.
      b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
      c. Refrigerant Charge: R-410A.
      d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 210/240.
   3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
   4. Fan: Aluminum-propeller type, directly connected to motor.
   5. Motor: Permanently lubricated, with integral thermal-overload protection.
   6. Low Ambient Kit: Permits operation down to 0 deg F.
   7. Mounting Base: Polyethylene.

B. Heat Recovery, Variable Refrigerant Volume Series (Simultaneous Heat/Cool Model)

1. General: The outdoor unit is designed specifically for use with VRV series components.
    a. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of a scroll compressor, motors, fans, condenser coil, electronic expansion valve, solenoid valves, 4 way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receivers and accumulators.
    b. Both liquid and suction lines must be individually insulated between the outdoor and indoor units.
    c. The outdoor unit can be wired and piped with outdoor unit access from left, right, rear or bottom.
    d. The connection ratio of indoor units to outdoor unit will be 50% to 130%.
    e. The sound pressure dB(A) at rated conditions shall be a value of 58 decibels at 3 feet from the front of the unit. The outdoor unit shall be capable of operating at further reduced noise during night time.
    f. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for re-programming.
    g. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
    h. The following safety devices shall be included on the condensing unit; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers. To ensure the liquid refrigerant does not flash when supplying to the various fan coil units, the circuit shall be provided with a sub-cooling feature. Oil recovery cycle shall be automatic occurring 1 hour after start of operation and then every 6 hours of operation.
    i. The outdoor unit shall be capable of heating operation at 0°F dry bulb ambient temperature without additional low ambient controls.
2. Unit Cabinet:
    a. The outdoor unit shall be completely weather proof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.
3. Fan:
    a. The condensing unit shall consist of one propeller type, direct-drive fan 750 W motors that have multiple speed operation via a DC inverter.
    b. The condensing unit fan motor shall have multiple speed operation of the DC inverter type, and be of high external static pressure and shall be factory set as standard at 0.12 in. WG with available by field setting switch to a maximum 0.24 in. WG pressure.

c. The fan shall be a vertical discharge configuration with an air flow of 7,400 cfm.
d. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
e. The fan motor shall be provided with a fan guard to prevent contact with moving parts.

4. Condenser Coil:
   a. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
   b. The coil shall be of a waffle louver fin and high heat exchanger, rifled bore tube design to ensure highly efficient performance.
   c. The coils shall be complete with corrosion treatment of an acrylic resin type. The thickness of the coating must be between 2.0 to 3.0 microns.
5. Compressor:
   a. The scroll compressor shall be variable speed (PAM inverter) controlled which is capable of changing the speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the condensing unit.
   b. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC, hermetically sealed scroll type with a maximum speed of 6,480 rpm.
   c. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
   d. The capacity control range shall be 14% to 100%, with 29 individual capacity steps. Each non-inverter compressor shall also be of the hermetically sealed scroll type.
   e. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
   f. Oil separators shall be standard with the equipment together with an oil balancing circuit.
   g. The compressor shall be mounted to avoid the transmission of vibration.
6. Electrical:
   a. The control voltage between the indoor and outdoor unit shall be 16VDC non-shielded 2 conductor cable.
   b. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable wire, thus simplifying the wiring operation.
   c. The control wiring lengths are:

	Outdoor to Indoor Unit	Outdoor to Central Controller	Indoor Unit to Remote Control
Control Wiring Length	6,665	3,330	1,665
Wire Type	2 wire, non-polarity, non-shielded		

2.6 BRANCH SELECTOR BOX FOR VRV HEAT RECOVERY SYSTEM

A. General: The branch selector boxes are designed specifically for use with VRV series heat recovery system components.
   1. These selector boxes shall be factory assembled, wired, and piped.
   2. The sum of connected capacity of all indoor air handlers shall range from 50% to 130% of rated capacity.
   3. These branch controllers must be run tested at the factory.
   4. These selector boxes must be mounted indoors.
   5. When simultaneously heating and cooling, the units in heating mode shall energize their sub cooling solenoid valve.

B. Unit Cabinet:
   1. These units shall have a galvanized steel plate casing.
   2. Each cabinet shall house multiple refrigeration control valves and a liquid gas separator.
   3. The cabinet shall contain a tube in tube heat exchanger.
   4. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

C. Refrigerant Valves:
   1. The unit shall be furnished with a 3-way refrigerant valve to control the direction of refrigerant flow.
   2. Electronic expansion valves shall be used to control the variable refrigerant flow.
   3. The refrigerant connections must be of the flare type.
   4. Two circuits may be connected to a branch selector box with the use of a REFNET joint provided they are within the capacity range of the branch selector.

D. Drainage:
   1. The unit shall not require drainage.

2.7 ACCESSORIES

A. Control is specified in Section 15900 "HVAC Instrumentation and Controls".

B. Thermostat: Low voltage with subbase to control compressor, evaporator fan, exhaust fan, and heat recovery units..

C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.
5. See Specification 15900 for more programmable thermostat details.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. 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.

F. Drain Hose: For condensate.

G. Additional Control:
1. Control exhaust fan.
2. Control heat recovery units.

H. Integrated Control System making VRV system and BMS system compatible.
1. BACnet protocol via Ethernet connection
2. 256 unit connectable

I. Automatic-reset timer to prevent rapid cycling of compressor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base that is 4 inches (100 mm) larger, on each side, than unit. Concrete, reinforcement, and formwork are specified in Section 03300 "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install ground-mounted, compressor-condenser components on polyethylene mounting base.

E. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 07720 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

F. Install seismic restraints.

G. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch (25 mm). See Section 15074 "Vibration and Seismic Controls for HVAC Piping and Equipment."

H. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   1. Remote, Water-Cooled Condenser Connections: Comply with requirements specified in Section 15181 "Hydronic Piping." Connect hydronic piping to supply and return 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.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 15815 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply[and return] ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 15820 "Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. 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.

C. 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.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

+ + END OF SECTION + +

SECTION 15756

DESICCANT DEHUMIDIFICATION UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes packaged, factory-assembled and -tested, desiccant-type, dehumidification units designed for a rugged indoor installation.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Dehumidification units shall withstand the effects of earthquake motions determined according to structural plans and specifications.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.

1.4 ACTION SUBMITTALS

A. Product Data: For each dehumidification unit indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each dehumidification unit indicated. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, center gravity, lifting points, and location and size of each field connection.
   2. Controls: Comply with shop drawing requirements in Division 15 Section "HVAC Instrumentation and Controls" for control equipment.
   3. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For dehumidification units 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.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For dehumidification unit accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For dehumidification units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: Two (2) set(s) of each type of filter specified.
   2. Fan Belts: Two (2) set(s) for each belt-drive fan.

1.8 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. ASHRAE Compliance:
   1. Applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment" and Section 7, "Construction and Startup."
   2. Applicable requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

B. Coordinate installation of roof curbs, equipment supports, roof penetrations, and wall penetrations with structure, electrical components, and plumbing/piping components.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of dehumidification units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Compressors: Manufacturer's standard, but not less than 5 years from date of Substantial Completion."
   2. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bry-Aire
   2. CDIMS
   3. Munters
   4. or approved equal

2.2 CASINGS

A. Casing: Double-wall construction with corrosion-protective coating and exterior baked-enamel finish, stainless-steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.
   1. Access: Hinged access doors with neoprene gaskets.
   2. Insulation: Minimum 2-inch- (50-mm-) thick insulation with no metal structure through the insulation.
   3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Drain Pan and Connection: Stainless steel; insulated and complying with ASHRAE 62.1.

2.3 DESICCANT WHEEL DEHUMIDIFIER

A. The dehumidifier shall include a desiccant wheel utilizing a fractional horsepower electric motor and a speed reducer process and reactivation air flow indicating devices, direct gas fired reactivation heater, reactivation fan/motor assembly, reactivation energy modulation system, electric/mechanical rotation fault circuitry and necessary manual and automatic dampers for proper functioning of the unit under all operating conditions.

B. Dehumidifier shall be rotary type, designed for continuous operation, and arranged to provide a counter flow of process and reactivation air streams with full-face pressure seals or low-friction contact seals on both sides to prevent cross leakage for external static pressure of up to 622 Pa (2.5 inches w.g.).

C. Desiccant rotor shall have synthesized silica gel, enhanced with titanium, bonded to a ceramic matrix, with filled voids and encapsulating the ceramic. Driver shall be a motor with adjustable drive sheaves and belt-tensioning idler pulley or adjustable motor mount.

D. The rotary desiccant shall transfer water in the vapor phase. The design and geometry shall provide for laminar flow over the operating range for minimum pressure loss with maximum transfer surface and minimum power requirements. The desiccant shall be a permanent integral part of the structure.

2.4 FANS

A. Supply Fans: Air foil, centrifugal; Class II construction, galvanized steel with baked-enamel finish; belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing of dehumidification unit.

B. Reactivation Fans: Air Foil, centrifugal; Class III construction, galvanized steel with baked-enamel finish; belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing of dehumidification unit.

C. Fan Motor: Comply with requirements in Division 15 Section "Common Motor Requirements for HVAC Equipment."
   1. Enclosure Type: Totally enclosed, fan cooled.

2.5 FILTERS

A. Glass Fiber: Minimum 85 – 90 percent arrestance according to ASHRAE 52.1, and MERV 6 according to ASHRAE 52.2.

B. Pleated: Minimum >90 percent arrestance according to ASHRAE 52.1, and MERV 8 according to ASHRAE 52.2.

2.6 REFRIGERATION SYSTEM

A. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1.

B. Refrigerant Coils: Copper tubes with mechanically bonded aluminum fins; factory fabricated and tested to comply with ASHRAE 33 and ARI 410; with multiple refrigerant circuits, seamless-copper headers with brazed connections, and stainless-steel frame. Coil and fins shall have a polyester coating. Coils shall have a minimum 300-psig (2070-kPa) working-pressure rating and be factory tested to 450 psig (3105 kPa) and to 300 psig (2070 kPa) while underwater.

C. Compressors: Hermetic, scroll compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-dryers, sight glasses, compressor service valves, and liquid- and suction-line service valves.
   1. Number of Refrigerant Circuits: Two for compressor capacities more than 7-1/2 tons (26.4 kW).
   2. Refrigerant: R-410A.
   3. Capacity Control:
      a. Hot-gas bypass valve and piping on one compressor.
      b. Cycle compressor.
   4. Low-Pressure Cutout: Manual reset after three automatic-reset failures.
   5. High-Pressure Cutout: Manual reset.
   6. Compressor Motor Overload Protection: Manual reset.
   7. Antirecycling Timing Device: Prevent compressor restart for five minutes after shutdown.
   8. Defrost Cycle: Adjustable timer shuts off supply fan. Compressor cycles until suction line temperature confirms thawed evaporator coil.

2.7 REMOTE-MOUNTED, AIR-COOLED CONDENSER UNIT

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. Refrigerant Coil: ARI 210/240, copper tube with mechanically bonded aluminum fins; with liquid subcooler.

C. Fan: Aluminum-propeller type, directly connected to permanently lubricated motor with integral thermal-overload protection.

D. Adjustable, Low Ambient Head-Pressure Control: Designed to operate at temperatures as low as 0 deg F (minus 18 deg C) by cycling condenser fans and controlling speed of last fan of each circuit.

E. Mounting Base: Polyethylene.

2.8 INDIRECT FIRED GAS FURNACE – PROCESS AIR

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and NFPA 54, "National Fuel Gas Code."
   1. AGA Approval: Designed and certified by and bearing label of AGA.
   2. Burners: Stainless steel.
      a. Gas Control Valve: Modulating.
      b. Fuel: Natural gas.
      c. Minimum Combustion Efficiency: 80 percent.
      d. Ignition: Electronically controlled electric spark with flame sensor.
      e. High-Altitude Kit: For Project elevation above sea level.

B. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.

C. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.

D. Inside Unit External Housing: Steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.

E. Downstream Application: Listed for application downstream of the supply fan and dx cooling coil.

F. Internal Casing: Aluminized steel, arranged to contain airflow, with duct flanges at inlet and outlet.

G. Heat Exchanger: Stainless steel.

H. Heat-Exchanger Drain Pan: Stainless steel.

I. Safety Controls:
   1. Vent Flow Verification: Flame rollout switch.
   2. Control Transformer: 24-V ac.
   3. High Limit: Thermal switch or fuse to stop burner.
   4. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
   5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
   6. Gas Manifold: Safety switches and controls to comply with ANSI standards and IRI.
   7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
   8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.

9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.9 DIRECT-FIRED GAS FURNACE – REACTIVATION AIR

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters"; and NFPA 54, "National Fuel Gas Code."

B. Inside Unit External Housing: Steel cabinet with integral support inserts.

C. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts.
   1. External Casing and Cabinet Finish: Powder coating over corrosion-resistant-treated surface in color to match fan section.

D. Burners: Cast-iron burner with stainless-steel mixing plates.
   1. Control Valve: Modulating with minimum turndown ratio of 25:1.
   2. Fuel: Natural gas.
   3. Pilot: Electrically ignited by hot-surface ceramic igniter.

E. Safety Controls:
   1. Gas Manifold: Safety switches and controls to comply with ANSI standards and IRI.
   2. Purge-Period Timer: Automatically delays burner ignition and bypasses low-limit control.
   3. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
   4. Manual-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
   5. Gas Train: Redundant, automatic main gas valves, electric pilot valve, electronic-modulating temperature control valve, main and pilot gas regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas pressure switches to comply with IRI requirements.
   6. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
   7. Control Transformer: Integrally mounted 24-V ac.

2.10 Variable-Frequency Controllers:

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, three-phase induction motor by adjusting output voltage and frequency.

B. Output Rating: Three-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

C. Unit Operating Requirements:
   1. Input ac voltage tolerance of 380 to 500 V, plus or minus 10 percent.
   2. Input-frequency tolerance of 50/60 Hz, plus or minus 6 percent.
   3. Minimum Efficiency: 96 percent at 60 Hz, full load.
   4. Minimum Displacement Primary-Side Power Factor: 96 percent.
   5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
   6. Starting Torque: 100 percent of rated torque or as indicated.
   7. Speed Regulation: Plus or minus 1 percent.

D. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

E. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 2 seconds to a minimum of 22 seconds.
   4. Deceleration: 2 seconds to a minimum of 22 seconds.
   5. Current Limit: 50 percent to a minimum of 110 percent of maximum rating.

F. Self-Protection and Reliability Features:
   1. Input transient protection by means of surge suppressors.
   2. Undervoltage and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
   3. Adjustable motor overload relays capable of NEMA ICS 2, Class 30 performance.
   4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
   5. Instantaneous line-to-line and line-to-ground overcurrent trips.
   6. Loss-of-phase protection.
   7. Reverse-phase protection.
   8. Short-circuit protection.
   9. Motor overtemperature fault.

G. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads, spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

H. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.

I. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

J. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back, based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

K. Door-mounted, digital status lights shall indicate the following conditions:
   1. Power on.
   2. Run.
   3. Overvoltage.
   4. Line fault.
   5. Overcurrent.
   6. External fault.

L. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual-speed-control potentiometer and elapsed-time meter.

M. Meters or digital readout devices and selector switch, mounted flush in controller door and connected, to indicate the following controller parameters:
   1. Output frequency (Hertz).
   2. Motor speed (rpm).
   3. Motor status (running, stop, fault).
   4. Motor current (amperes).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. Proportional-integral-derivative feedback signal (percent).
   8. DC-link voltage (volts dc).
   9. Set-point frequency (Hertz).
   10. Motor output voltage (volts).

N. Control Signal Interface:
   1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
   2. Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:
      a. 0 to 10-V dc.
      b. 0-20 or 4-20 mA.
      c. Potentiometer using up/down digital inputs.
      d. Fixed frequencies using digital inputs.
      e. RS485.
      f. Keypad display for local hand operation.
   3. Output signal interface with a minimum of one analog output signal (0/4-20 mA), which can be programmed to any of the following:
      a. Output frequency (Hertz).
      b. Output current (load).
      c. DC-link voltage (volts dc).
      d. Motor torque (percent).
      e. Motor speed (rpm).
      f. Set-point frequency (Hertz).

4. Remote indication interface with a minimum of two dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
    a. Motor running.
    b. Set-point speed reached.
    c. Fault and warning indication (overtemperature or overcurrent).
    d. High- or low-speed limits reached.

O. Communications: RS485 interface allows VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

P. Integral Disconnecting Means: NEMA KS 1, nonfusible switch with lockable handle.

Q. Accessories:
1. Devices shall be factory installed in controller enclosure unless otherwise indicated.
2. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
3. Standard Displays:
    a. Output frequency (Hertz).
    b. Set-point frequency (Hertz).
    c. Motor current (amperes).
    d. DC-link voltage (volts dc).
    e. Motor torque (percent).
    f. Motor speed (rpm).
    g. Motor output voltage (volts).

2.11 DAMPERS

A. Face-and-Bypass Dampers: Opposed-blade, extruded-aluminum dampers with cadmium-plated steel operating rods rotating in sintered bronze or nylon bearings with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with cadmium-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single extruded-aluminum frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).

C. Damper Operator: 24-V ac, close coupled, with gear train sealed in oil and with spring return.

2.12 CONTROLS

A. Comply with requirements in Division 15 Section "HVAC Instrumentation and Controls" for control equipment.

B. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.

C. Building Automation System Interface: Factory-installed hardware and software to enable the building automation system to monitor, control, and display status and alarms.

D. Operating Control: Room dewpoint sensor and process water sensor shall be used to maintain space dewpoint temperature 5°F below process water temperature.

E. Operating Controls: Factory-installed microprocessor controller, capable of being remotely mounted.
   1. Display the following on the face of controller:
      a. System on.
      b. System dehumidifying mode.
      c. System air-conditioning mode.
      d. System outdoor-air (economizer) mode.
      e. System space heat mode.
      f. Unit requires service.
      g. Return-air (space) temperature.
      h. Return-air (space) dew point temperature.
      i. Space dew point temperature set point.
      j. Process-water temperature.
      k. Outdoor-air temperature.
      l. Outdoor-air dew point temperature.
      m. Filter(s) pressure drop digital display.
      n. Status: Airflow, fans, system, unit operation, and operating mode.
      o. Alarm digital display.
      p. Control set point temperatures
      q. Service codes.

   2. Indicate the following sensor failures on panel:
      a. Airflow: Dirty air filter, blocked airflow, and fan failure.
      b. Refrigerant high and low pressure.
      c. High and low evaporator temperature.
      d. Communication fault.
      e. System off.
      f. Antishort cycle delay.
      g. Power failure.

3. Provide access to the following set points on panel:
    a. Space temperature.
    b. Space relative humidity.
    c. Economizer/air-conditioning/heating changeover temperature.
    d. Airflow alarm.
4. Provide the following displays on panel:
    a. Space temperature.
    b. Space relative humidity.
    c. Outdoor-air temperature.
    d. Supply-air temperature.
    e. Process water temperature.
    f. Airflow rate.
    g. Air-off evaporator temperature.
    h. Return-air dewpoint temperature.
    i. Service codes.
5. Provide the following controls on panel:
    a. System on-off, fan continues to run.
    b. Fan on-off.
    c. Service codes access.

F. Operating Controls: Factory-installed microprocessor controller.
1. Factory-installed operator panel with backlit display, capable of being remotely mounted, allows menu-driven display for navigation and control of unit.
2. Integral clock.
3. Personal computer interface.
4. Integral local area network for direct connection to BACnet.
5. Factory programmed.
6. Unit-Mounted Sensors:
    a. Airflow switch.
    b. Discharge temperature.
    c. Evaporator-air temperature.
    d. Relative humidity.
    e. Return-air temperature.
    f. Supply-air temperature.
7. Integral diagnostics.
8. Nonvolatile memory.
9. IP or SI display.
10. Provide the following status and alarm functions:
    a. System: On-off.
    b. Power failure.
    c. Fan: Off, overload.
    d. Compressor: On, turned off, overload, high pressure, low pressure, overheat, oil failure, and pumpdown.
    e. Evaporator damper closed.
    f. Dehumidification: Call for, on.
    g. Air Conditioning: Call for, on.

h. System outdoor-air (economizer) mode.
i. Auxiliary space heat on.
j. Alarms: Firestat, freezestat, and filters.

11. Provide the following controls via operator panel:
    a. Compressor auto-off.
    b. Fan auto-off.
    c. Set-Point Adjustments: Relative humidity, temperatures, deadbands, and differentials.
    d. Sensor calibration.
12. Monitor constant and variable motor loads.
13. Monitor cooling load.
14. Monitor economizer cycles.
15. Monitor ventilation air volumes.

2.13 ACCESSORIES

A. Smoke Detectors: Photoelectric detector located in return-air plenum, to de-energize unit.
   1. Operating Voltage: 24-V dc, nominal.
   2. Self-Restoring: Detectors do not require resetting or readjusting after actuation to restore them to normal operation.
   3. Plug-in Arrangement: Detector and associated electronic components mounted in module with tamper-resistant connection to fixed base with twist-locking plug. Terminals in fixed base accept building wiring.
   4. Integral Visual-Indicating Light: Digital-display type indicating detector operation.
   5. Sensitivity: Can be tested and adjusted in-place after installation.
   6. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the fire-alarm control panel.
   7. Sensor: Digital display or infrared light source with matching silicon-cell receiver.
   8. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) of smoke obscuration when tested according to UL 268A.
   9. Integral Thermal Detector: Fixed-temperature type with 135 deg F (57 deg C) setting.

2.14 SOURCE QUALITY CONTROL

A. Verification of Performance: Factory test and rate dehumidification units according to ARI 910.

B. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to ARI 575.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.

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

3.2 INSTALLATION

A. Equipment Mounting: Install dehumidification units on concrete base(s) using restrained spring isolators. Comply with requirements for concrete base(s) specified in Division 3 Section "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
   1. Minimum Deflection: 1/4 inch (6 mm).
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

3.3 CONNECTIONS

A. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.

B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.

C. Connect condensate drain pans using minimum NPS 1-1/4 (DN 32) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.

D. Refrigerant Piping: Comply with requirements in Division 15 Section "Refrigerant Piping." Connect to supply and return coil tappings with shutoff valve and union or flange at each connection.

E. Duct installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination in machine-mounted frames and/or louvers.
2. Slope reactivation duct toward drain or discharge louver.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. 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.

C. Tests and Inspections:
   1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
   2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Dehumidification unit will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

B. Perform the following final checks before startup:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Perform cleaning and adjusting specified in this Section.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
   5. Check lubrication of bearings, pulleys, belts, and other moving parts.
   6. Set outside- and return-air mixing dampers to minimum outside-air setting.
   7. Install clean filters.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for dehumidification units include the following:
   1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
   2. Measure and record motor's electrical values for voltage and amperage.
   3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Comply with requirements in Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing of dehumidification unit.

E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust initial temperature and humidity set points.

3.7 CLEANING

A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.

B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain dehumidification units.

+ + END OF SECTION + +

SECTION 15762

UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Propeller unit heaters with electric-resistance heating coils.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CWP: Cold working pressure.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Plans, elevations, sections, and details.
   2. Location and size of each field connection.
   3. Details of anchorages and attachments to structure and to supported equipment.
   4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
   5. Location and arrangement of piping valves and specialties.
   6. Location and arrangement of integral controls.
   7. Wiring Diagrams: Power, signal, and control wiring.

C. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

D. Samples for Verification: Finish colors for each type of cabinet unit heater and wall and ceiling heaters indicated with factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which unit heaters will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   6. Perimeter moldings for exposed or partially exposed cabinets.

B. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Wash Down Unit Heater Filters: Furnish two spare filter(s) for each filter installed.

1.8 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 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 WASH DOWN CORROSION-RESISTANT UNIT HEATERS

A. Available Manufacturers: See Unit Heater schedule.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Airtherm; a Mestek Company.
   2. Engineered Air Ltd.
   3. Indeeco.
   4. McQuay International.
   5. Rosemex Products.
   6. Ruffneck Heaters; a division of Lexa Corporation.
   7. Trane.

C. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

D. Comply with UL 2021.

E. Comply with UL 823.

F. Cabinet: Removable panels for maintenance access to controls.

G. Cabinet Finish: 16-gauge stainless steel factory-assembled and -tested propeller unit heater before shipping.

H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

I. Discharge Louver: Adjustable stainless steel grille for horizontal units.

J. General Coil Requirements: NEMA 4X control enclosure.

K. Electric-Resistance Heating Elements: 304 stainless steel finned tube elements, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in stainless corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). Element ends shall be enclosed in non-metalic NEMA 4X terminal box. Fin surface temperature shall not exceed 550 deg F (288 deg C) at any point during normal operation.
   1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
   2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

L. Fan: Propeller type with epoxy-coated aluminum wheel directly mounted on motor shaft in the fan venturi.

M. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements for HVAC Equipment."
   1. Motor Type: Permanently lubricated, TEFC.

N. Control Devices:
   1. Unit-mounted thermostat.

O. Capacities and Characteristics (See Unit Heater schedule).

2.2 WALL HEATERS

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:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Berko Electric Heating; a division of Marley Engineered Products.
   2. Chromalox, Inc.; a division of Emerson Electric Company.
   3. Indeeco.
   4. Markel Products; a division of TPI Corporation.
   5. Marley Electric Heating; a division of Marley Engineered Products.
   6. Ouellet Canada Inc.
   7. QMark Electric Heating; a division of Marley Engineered Products.

8. Trane.

C. Description: An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

D. Cabinet:
   1. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.
   2. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
   3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Surface-Mounting Cabinet Enclosure: Steel with finish to match cabinet.

F. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high temperature protection. Provide integral circuit breaker for overcurrent protection.

G. Fan: Aluminum propeller directly connected to motor.
   1. Motor: Permanently lubricated. Comply with requirements in Section 15058 "Common Motor Requirements for HVAC Equipment."

H. Controls: Unit-mounted thermostat.

I. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for electrical connections to verify actual locations before unit heater installation.

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

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 7 Section "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Install propeller unit heaters level and plumb.

D. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints. Vibration isolators and seismic restraints are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

E. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers. Hanger rods and attachments to structure are specified in Division 15 Section "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

G. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Comply with safety requirements in UL 1995.

D. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 15 Section "Hydronic Piping."

E. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of unit heater. Steam specialties are specified in Division 15 Section "Steam and Condensate Piping."

F. Ground equipment according to Division 16 Section "Grounding and Bonding."

G. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of 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.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Division 1 Section "Demonstration and Training."

+ + END OF SECTION + +

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SECTION 15785

AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Packaged energy recovery units.

1.3 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.

B. Seismic Performance: See Structural Drawings.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For air-to-air energy recovery equipment 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. Detail fabrication and assembly of air-to-air energy recovery equipment.
   2. 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.

3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which equipment or suspension systems will be attached.

B. Seismic Qualification Certificates: For air-to-air energy recovery equipment, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: Two sets of each type of filter specified.
   2. Fan Belts: One set of belts for each belt-driven fan in energy recovery units.
   3. Wheel Belts: One set of belts for each heat wheel.

1.8 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. ARI Compliance:
   1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."

2. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."

C. ASHRAE Compliance:
   1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
   2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

E. UL Compliance:
   1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
   2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

1.9 COORDINATION

A. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Packaged Energy Recovery Units: Two years.

PART 2 - PRODUCTS

2.1 PACKAGED ENERGY RECOVERY UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carnes.

2. Des Champs Technologies.
3. Engineered Air.
4. Gaylord Industries, Inc.
5. Greenheck Fan Corporation.
6. Loren Cook Company.
7. SEMCO Incorporated.
8. Trane; American Standard Companies, Inc.

B. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, hinged access doors with neoprene gaskets for inspection and access to internal parts, minimum 1-inch- (25-mm-) thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.

D. Heat Recovery Device: Heat wheel or fixed plate heat exchanger.

E. Supply and Exhaust Fans: Backward-inclined, SWSI centrifugal fan with spring isolators and insulated flexible duct connections.
1. Motor and Drive: Direct driven.
2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 15058 "Common Motor Requirements for HVAC Equipment."
3. 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.
4. Spring isolators on each fan.

F. Extended-Surface, Disposable Panel Filters:
1. Comply with NFPA 90A.
2. 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 lift out from access plenum.
3. Factory-fabricated, dry, extended-surface type.
4. Thickness: 1 inch (25 mm).
5. Minimum Merv: 7, according to ASHRAE 52.2.
6. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent and held by self-supporting wire grid.
7. Media-Grid Frame: Nonflammable cardboard.
8. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

G. Condensate Drain Pans:

1. Fabricated from stainless-steel sheet and sloped in multiple planes to collect and drain condensate from cooling coils, coil piping connections, coil headers, and return bends.
2. Complying with requirements in ASHRAE 62.1.
3. Drain Connections: At low point of pan with minimum 1/2 inch threaded nipple.
4. Units with stacked coils shall have an intermediate drain pan to collect and drain condensate from top coil.

H. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.
1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
2. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
3. Include nonfused disconnect switches.

I. Accessories:
1. Duct flanges.
2. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, extruded-aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals, in parallel-blade arrangement with cadmium-plated steel operating rods rotating in stainless-steel sleeve bearings mounted in a single extruded-aluminum frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).
3. Rubber-in-shear isolators for ceiling-mounted units.
4. Hinged access doors with quarter-turn latches.
5. Drain pans for condensate removal complying with ASHRAE 62.1.

2.2 CONTROLS

A. Interface: Factory-installed, solid-state microprocessor-based unit for connection to heat pump programmable thermostat for occupied/unoccupied mode and unit on/off.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
   1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
   2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
   3. Access doors and panels are specified in Section 15820 "Duct Accessories."

B. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.
   1. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Section 15820 "Duct Accessories."

C. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 15074 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Install units with clearances for service and maintenance.

E. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

F. Pipe drains from drain pans to nearest floor drain; use ASTM B 88, Type L (ASTM B 88M, Type B), drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

G. Pipe drains from drain pans to nearest floor drain; use ASTM D 1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.
   1. Requirements for Low-Emitting Materials:
      a. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
      b. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Requirements for Low-Emitting Materials: Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

3.3 CONNECTIONS

A. Install piping adjacent to unit to allow service and maintenance.

B. Connect piping to units mounted on vibration isolators with flexible connectors.

C. Connect condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

D. Comply with requirements for ductwork specified in Section 15815 "Metal Ducts."

E. Install electrical devices furnished with units but not factory mounted.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. 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.

C. Tests and Inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Adjust seals and purge.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Set initial temperature and humidity set points.
   5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

+ + END OF SECTION + +

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SECTION 15815

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.
   3. Sheet metal materials.
   4. Sealants and gaskets.
   5. Hangers and supports.
   6. Seismic-restraint devices.

B. Related Sections:
   1. Division 15 Section "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
   2. Division 15 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
   3. Division 15 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
   4. Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing requirements for metal ducts.

1.3 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 and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" andSMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." See Structural plans.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Adhesives.
   2. Sealants and gaskets.
   3. Seismic-restraint devices.

B. Shop Drawings:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Factory- and shop-fabricated ducts and fittings.
   3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
   4. Elevation of top of ducts.
   5. 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, seismic restraints, 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, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. 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.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

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

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 D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, 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 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."

C. 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."

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 4, "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 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. Lindab Inc.
      b. McGill AirFlow LLC.
      c. SEMCO Incorporated.
      d. Sheet Metal Connectors, Inc.
      e. Spiral Manufacturing Co., Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. 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."
   1. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.

D. 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."

1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

E. 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."

2.3 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: G90 (Z275).
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M. Type 316, Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4.

D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

E. Factory- or Shop-Applied Antimicrobial Coating:
1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: White.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

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: Not permitted.

2.4 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 (102 mm).
   3. Sealant: Modified styrene acrylic.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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 (2500 Pa), 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. Solvent-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Base: Synthetic rubber resin.
   3. Solvent: Toluene and heptane.
   4. Solids Content: Minimum 60 percent.
   5. Shore A Hardness: Minimum 60.
   6. Water resistant.
   7. Mold and mildew resistant.
   8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   9. VOC: Maximum 395 g/L.
   10. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
   11. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
   12. Service: Indoor or outdoor.
   13. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. 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, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:
   1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) 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.

2.5 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 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "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.

2.6 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper B-Line, Inc.; a division of Cooper Industries.
   2. Ductmate Industries, Inc.
   3. Hilti Corp.
   4. Kinetics Noise Control.
   5. Loos & Co.; Cableware Division.
   6. Mason Industries.
   7. TOLCO; a brand of NIBCO INC.
   8. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

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 (25 mm), 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 (38 mm).

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 "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "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 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 (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): 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 (500 Pa) and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "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 (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) 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 (5 m).

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.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" and Structural plans.
   1. Space lateral supports a maximum of 20 feet (6 m) o.c., and longitudinal supports a maximum of 40 feet (12 m) o.c.
   2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect 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 applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 15 Section "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 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9 painting Sections.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   2. Test the all the duct systems:
      a. Test to a Pressure Class of 2-Inch wg (500 Pa): Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
   4. Test for leaks before applying external insulation.
   5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
   6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.
   2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 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.

3.10 START UP

A. Air Balance: Comply with requirements in Division 15 Section "Testing, Adjusting, and Balancing."

3.11 DUCT SCHEDULE

A. Supply Ducts:
   1. Ducts Connected to Constant-Volume Air-Handling Units:
      a. Pressure Class: Positive 2-inch wg (500 Pa).
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Round and Flat Oval: 12.

B. Return Ducts:
   1. Ducts Connected to Air-Handling Units:
      a. Pressure Class: Negative 2-inch wg (500 Pa).
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Round and Flat Oval: 12.

C. Exhaust Ducts:
   1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
      a. Pressure Class: Negative 2-inch wg (500 Pa).
      b. Minimum SMACNA Seal Class: A if negative pressure.
      c. SMACNA Leakage Class for Round and Flat Oval: 12.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
   1. Ducts Connected to Air-Handling Units:
      a. Pressure Class: Positive or negative 2-inch wg (500 Pa.
      b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 24.

E. Intermediate Reinforcement: Not permitted.

F. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "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.
   b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Welded.

G. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
   c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

+ + END OF SECTION + +

SECTION 15816

NONMETAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Thermoset FRP ducts and fittings.

B. Related Sections:
   1. Division 15 Section "Metal Ducts" for single- and double-wall, rectangular and round ducts.
   2. Division 15 Section "Duct Accessories" for dampers, duct-mounting access doors and panels, turning vanes, and flexible ducts.
   3. Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing requirements for nonmetal ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions to comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
   1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Thermoset FRP duct materials.

B. Shop Drawings:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Duct layout indicating sizes and pressure classes.
   3. Elevation of top of ducts.

4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project.
10. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:
1. Duct materials and thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

C. NFPA Compliance:
1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 THERMOSET FRP DUCTS AND FITTINGS

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. McGill AirFlow LLC.
2. Perry Fiberglass Products, Inc.
3. Spunstrand Inc.

B. Duct and Fittings:
   1. Thermoset FRP Resin: Manufacture duct with resin that complies with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E 84.
   2. Round Duct: ASTM D 2996, Type I, Grade 2, Class E, filament-wound duct, minimum 0.125-inch (3.2-mm) wall thickness, with tapered bell and spigot ends for adhesive joints, or plain ends with couplings.
   3. Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and joining method as duct.
   4. Rectangular Fittings: Minimum 0.125-inch- (3.2-mm-) thick flat sheet with fiberglass roving and resin-reinforced joints and seams.

C. Joining Materials: Roving and polyester resin.
   1. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Fabrication:
   1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."
   2. Fabricate 90-degree rectangular mitered elbows to include turning vanes, 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.

2.2 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 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables: ASTM A 492, stainless steel with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

2.3 SEISMIC-RESTRAINT DEVICES

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. Cooper B-Line, Inc.; a division of Cooper Industries.
   2. Ductmate Industries, Inc.
   3. Hilti Corp.
   4. Kinetics Noise Control.
   5. Mason Industries.
   6. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Install ducts with fewest possible joints.

B. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

C. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
D. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

E. 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. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

F. 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.

G. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

H. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."

3.2 HANGER AND SUPPORT INSTALLATION

A. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. 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 (100 mm) thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. 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.

3.3 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
   1. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
   2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select sizes of components so strength will be adequate to carry present and future static and seismic loads within restraint device capacity.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints where ducts are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect 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 applications and stainless-steel anchors for applications exposed to weather.

3.4 PAINTING

A. Paint interior of thermoset FRP ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9 painting Sections.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 START UP

A. Air Balance: Comply with requirements in Division 15 Section "Testing, Adjusting, and Balancing."

3.7 DUCT SCHEDULE

A. Indoor Exhaust Ducts and Fittings:
   1. Thermoset FRP Rectangular Ducts and Fittings:
      a. Pressure Class: 12" wg (3000 Pa).
      b. Minimum Wall Thickness: 0.125".
   2. Thermoset FRP Round Ducts and Fittings.
      a. Pressure Class: 12" wg (3000 Pa).
      b. Minimum Wall Thickness:
         1) 20" dia. and less: 0.125"
         2) 21" – 36" dia.: 0.187".
         3) 37" and greater: 0.25".

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SECTION 15820

DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Backdraft and pressure relief dampers.
   2. Manual volume dampers.
   3. Flange connectors.
   4. Duct-mounted access doors.
   5. Flexible connectors.
   6. Flexible ducts.
   7. Duct accessory hardware.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. 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, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
      e. Duct security bars.
      f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90 (Z275).
   2. Exposed-Surface Finish: Mill phosphatized.

B. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of 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. Greenheck Fan Corporation.
   5. Lloyd Industries, Inc.
   6. Nailor Industries Inc.
   7. NCA Manufacturing, Inc.
   8. Pottorff.
   9. Ruskin Company.
   10. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1000 fpm (5.1 m/s.

D. Maximum System Pressure: 2-inch wg (0.5 kPa).

E. Frame: Hat-shaped, 0.05-inch- (1.3-mm-) thick, galvanized sheet steel, with welded corners or mechanically attached[and mounting flange].

F. Blades: Multiple single-piece blades, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:
   1. Material: Galvanized steel, Aluminum.
   2. Diameter: 0.20 inch (5 mm).

J. Tie Bars and Brackets: Aluminum.

K. Return Spring: Adjustable tension.

L. Bearings: Synthetic pivot bushings.

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 (1.0 mm) minimum.
    b. Sleeve Length: 6 inches (152 mm) minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Bird.
9. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
    1. Manufacturers: Subject to compliance with requirements, provide products by one of 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. Nailor Industries Inc.
        f. Pottorff.
        g. Ruskin Company.
        h. Trox USA Inc.
        i. Vent Products Company, Inc.
    2. Standard leakage rating.
    3. Suitable for horizontal or vertical applications.
    4. Frames:
        a. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel.
        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 (1.62 mm) thick.
    6. Blade Axles: Galvanized steel.
    7. Bearings:
        a. Molded synthetic.
        b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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.

2.5 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of 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.

2.6 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of 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. Elgen Manufacturing.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. McGill AirFlow LLC.
8. Nailor Industries Inc.
9. Pottorff.
10. Ventfabrics, Inc.
11. 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 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch (25-by-25-mm)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 (300 mm) Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.

2.7 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of 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 (1.3-mm) 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 (1093 deg C).

F. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.8 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. Elgen Manufacturing.
   4. Ventfabrics, Inc.
   5. 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 (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) 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. (880 g/sq. m).
   2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

F. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
   1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).

2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

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 (6-mm) movement at start and stop.

2.9 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

C. 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 (75 through 460 mm), to suit duct size.
2. Non-Clamp Connectors: Liquid adhesive plus tape.

2.10 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 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 and downstream 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. Elsewhere as indicated.

H. Install access doors with swing against duct static pressure.

I. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
   2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
   3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).

J. Label access doors according to Division 15 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

K. Install flexible connectors to connect ducts to equipment.

L. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

M. Connect diffusers or light troffer boots to ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

N. Connect flexible ducts to metal ducts with draw bands.

O. Install duct test holes where required for testing and balancing purposes.

P. 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 (6-mm) 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, smoke, and combination 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.
   5. Operate remote damper operators to verify full range of movement of operator and damper.

+ + END OF SECTION + +

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SECTION 15838

POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Upblast propeller roof exhaust fans with hoods.
   2. Centrifugal wall ventilators.
   3. In-line centrifugal fans.
   4. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For unit hangars and 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. 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.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.8 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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 UPBLAST PROPELLER ROOF EXHAUST FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carnes Company.
   2. Cincinnati Fan.
   3. Greenheck Fan Corporation.
   4. Hartzell Fan Incorporated.
   5. JencoFan.
   6. Loren Cook Company
   7. New York Blower Company (The).
   8. PennBarry.

B. Fan Hood, Fan Housing, and Base: Reinforced and braced aluminum, containing aluminum arched hood panels with interlocking ribs, damper and rain trough, motor and drive assembly, and fan wheel. Base access door for service and inspection of damper and actuator.
   1. Damper Rods: Steel with bronze bearings.
   2. Base: Aluminum permitting service and maintenance.
   3. Birdscreens of 0.5 inch aluminum mesh horizontally in discharge perimeter of hood.

C. Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

D. Belt Drives:
   1. Resiliently mounted to housing.
   2. Weatherproof housing of same material as fan housing.
   3. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   4. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
   5. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   6. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.

E. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in cant and mounting flange.
2. Overall Height: 12 inches (300 mm).
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Mounting Pedestal: Galvanized steel with removable access panel.

2.2 CENTRIFUGAL WALL VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   1. Carnes Company.
   2. Greenheck Fan Corporation.
   3. Hartzell Fan Incorporated.
   4. JencoFan.
   5. Loren Cook Company.
   6. PennBarry.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Accessories:
   1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
   2. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
   3. Wall Grille: Ring type for flush mounting.
   4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
   5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

E. Capacities and Characteristics: See schedule.

2.3 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carnes Company.
   2. Greenheck Fan Corporation.
   3. Hartzell fan Incorporated.
   4. JencoFan.
   5. Loren Cook Company.
   6. PennBarry.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:
   1. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
   2. Companion Flanges: For inlet and outlet duct connections.
   3. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.4 PROPELLER FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carnes Company.
   2. Chicago Blower Corporation.
   3. Cincinnati Fan.
   4. Greenheck.
   5. Hartzell Fan Incorporated.
   6. Howden Buffalo Inc.
   7. JencoFan.
   8. King Company; part of Mestek, Inc.
   9. Loren Cook Company.
   10. PennBarry.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

D. Aluminum Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

E. Fan Drive: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

F. Fan Drive:
   1. Resiliently mounted to housing.
   2. Statically and dynamically balanced.
   3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   4. Extend grease fitting to accessible location outside of unit.
   5. Service Factor Based on Fan Motor Size: 1.4.
   6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
      a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
   8. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
   9. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   10. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   11. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:
   1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
   2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
   3. Wall Sleeve: Galvanized steel to match fan and accessory size.
   4. Weathershield Hood: Galvanized steel to match fan and accessory size.
   5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
   6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

H. Capacities and Characteristics: See schedule.

2.5 MOTORS

A. Comply with NEMA, MG1 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.

B. Enclosure Type: Totally enclosed, fan cooled.

2.6 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using restrained elastomeric mounts having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounted units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

D. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

E. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Division 7 Section "Roof Accessories" for installation of roof curbs.

F. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

G. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

H. Install units with clearances for service and maintenance.

I. Label units according to requirements specified in Division 15 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

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. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
   8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

+ + END OF SECTION + +

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SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Rectangular and square ceiling diffusers.
   2. Modular core return/exhaust grilles.

B. Related Sections:
   1. Division 10 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
   2. Division 15 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling 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. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.

3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:
1. Manufacturers: Subject to compliance with requirements, provide products 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. Material: See schedule.
3. Finish: See schedule.
4. Face Size: See schedule.
5. Face Style: See schedule.
6. Mounting: See schedule.
7. Pattern: See schedule.
8. Dampers: See schedule.
9. Accessories: See schedule.

B. Egg Crate Exhaust/Return Grilles:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Air Research Diffuser Products, 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. Material: See schedule.
3. Grilles per Unit: See schedule.
4. Finish: See schedule..
5. Border: See schedule.
6. Blades: See schedule.
7. Modules: See schedule.
8. Mounting: See schedule.
9. Accessory: See schedule.

2.2 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 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 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.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

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SECTION 15900

HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:
   1. Division 15 Section "Meters and Gages" for measuring equipment that relates to this Section.
   2. Division 15 Section “Desiccant Dehumidification Units” for coordination that relates to this Section.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PID: Proportional plus integral plus derivative.

F. RTD: Resistance temperature detector.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
    a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
    b. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
    c. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
    d. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
    e. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
    f. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
    g. Carbon Monoxide: Plus or minus 5 percent of reading.

1.5 SEQUENCE OF OPERATION

A. See Plans. (H-00-701) for desiccant dehumidifier sequence.

B. Variable Volume Refrigerant Dx Split System (FCU-1A-D, ACCU-1)
1.. Supply Fan - Supply fan(s) shall be under control of the space temp/humidity controls (adjustable).
2. DX Coil – In cooling mode DX coil shall maintain space cooling temperature setpoint. In heating mode DX coil shall maintain space heating temperature setpoint.
3. Thermostat – Microprocessor based programmable T-stat with “Hand-Off-Cool” , “Auto-On” switches (modes), automatic heating/cooling change over, and 24/7 time clock for occupancy schedule shall control the system. In heating position the heat pump reversing valve shall be positioned to heat. In cooling position the reversing valve shall be positioned to cool. During Auto position the supply fan shall be under space temperature control. In the auto position the condensing unit shall be interlocked with the supply fan. Supply fan shall have an adjustable time delayed on/off. Spare auxiliary switches (I/O’s) integral to the thermostat shall control the exhaust fan (EF-1) and the heat recovery units (HRU-1 and 2). Exhaust fan and heat recovery units shall operate during occupied mode and shall not operate during unoccupied mode.

4. Occupied / Unoccupied Mode – Times of occupancy are from 6:00 am to 6:00 pm, and are adjustable

C. Single Zone Constant Volume DX Split System Elect Rm (FCU-2, ACCU-2)
   1. Supply Fan - Supply fan(s) shall be under control of the space temp/humidity controls (adjustable).
   2. DX Coil – In cooling mode DX coil shall maintain space cooling temperature setpoint. In heating mode DX coil shall maintain space heating temperature setpoint.
   3. Thermostat – Microprocessor based T-stat with "Hand-Off-Cool" , "Auto-On" switches (modes) and automatic heating/cooling change over shall control the system. In heating position the heat pump reversing valve shall be positioned to heat. In cooling position the reversing valve shall be positioned to cool. During Auto position the supply fan shall be under space temperature control. In the auto position the condensing unit shall be interlocked with the supply fan. Supply fan shall have an adjustable time delayed on/off.

D. Heat Recovery Unit (HRU-1 HRU-2)
   1. Fans – Supply and exhaust fan(s) shall operate continuously during occupied mode as determined by the lab/office (PT/GAC Bldg Lab/Office Area) schedule. During unoccupied mode the supply and exhaust fan(s) shall not operate.
   2. Outside Air and Exhaust Dampers – AO and EA dampers shall open when HRU fans operate and close when the fans stop.
   3. Heat Recovery Wheel – Heat wheel shall operate at constant speed during occupied mode. During unoccupied mode the heat recovery wheel shall not operate.
   4. HRU Control Interface – HRU's control shall be interlocked with the local heat pumps via the microprocessor based programmable thermostat.

E. Single Zone Constant Volume Dx Split System (Ahu-1 Accu-3)
   1. Supply Fan - Supply fan(s) shall be under control of the space temp/humidity controls (adjustable).
   2. DX Coil – In cooling mode DX coil shall maintain space cooling temperature setpoint. In heating mode DX coil shall maintain space heating temperature setpoint.
   3. Outside Air Damper – OA damper shall be interlocked with the supply fan.
   4. Thermostat – Microprocessor based T-stat with "Hand-Off-Cool" , "Auto-On" switches (modes) and automatic heating/cooling change over shall control the system. In heating position the heat pump reversing valve shall be positioned to heat. In cooling position the reversing valve shall be positioned to cool. During Auto position the supply fan shall be under space temperature control. In the auto position the condensing unit shall be interlocked with the supply fan. Supply fan shall have an adjustable time delayed on/off.

5. Emergency Electric Heat – During heating mode if space temperature drops 5 F below setpoint for more than 15 minutes (adjustable) emergency electric strip heat shall operate until space temperature meets setpoint.

1.6 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
   1. System Hardware: Include technical data for interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
   2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
   3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
   2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   3. Wiring Diagrams: Power, signal, and control wiring.
   4. Details of control panel faces, including controls, instruments, and labeling.
   5. Written description of sequence of operation.
   6. Schedule of dampers including size, leakage, and flow characteristics.
   7. Schedule of valves including flow characteristics.
   8. System Hardware:
      a. Wiring diagrams for control units with termination numbers.
      b. Schematic diagrams and floor plans for field sensors and control hardware.
      c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
   9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
   10. Controlled Systems:
      a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.

b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
c. Written description of sequence of operation including schematic diagram.
d. Points list.

C. Samples for Initial Selection: For each color required, of each type of thermostat or sensor cover with factory-applied color finishes.

D. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

1.7 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

B. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.

C. Qualification Data: For Installer and manufacturer.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

E. Field quality-control test reports.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:
1. Interconnection wiring diagrams with identified and numbered system components and devices.
2. Keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.

B. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.

4. Printout of software application and graphic screens.
5. Software license required by and installed for workstations and control systems.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Replacement Materials: One replacement relay mechanism for each unique controller thermostat.
   2. Maintenance Materials: Two (2) thermostat adjusting key(s).

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

B. 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.

C. Comply with ASHRAE 135 for DDC system components.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.12 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 13 Section “Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Division 16 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

E. Coordinate equipment with Division 16 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03300 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

A. Manufacturer: Stand alone. Indicate manufacturer.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
   1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.

2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
4. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.
5. Enclosure: Dustproof rated for operation at 32 to 120 deg F (0 to 50 deg C).
6. Enclosure: Waterproof rated for operation at 40 to 150 deg F (5 to 65 deg C).

2.4 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.
   1. Alarm Condition: Indicating light flashes and horn sounds.
   2. Acknowledge Switch: Horn is silent and indicating light is steady.
   3. Second Alarm: Horn sounds and indicating light is steady.
   4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
   5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.5 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F (minus 23 to plus 21 deg C), and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
   1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

2.6 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:
   1. Manufacturers:
      a. BEC Controls Corporation.
      b. Ebtron, Inc.
      c. Heat-Timer Corporation.
      d. I.T.M. Instruments Inc.
      e. MAMAC Systems, Inc.
      f. RDF Corporation.
      g. Or Approved Equal.
   2. Accuracy: Plus or minus 0.5 deg F (0.3 deg C) at calibration point.
   3. Wire: Twisted, shielded-pair cable.
   4. Insertion Elements in Ducts: Single point, 8 inches (200 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
   5. Averaging Elements in Ducts: 18 inches (460 mm) long, rigid; use where prone to temperature stratification or where ducts are larger than 10 sq. ft. (1 sq. m).
   6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64 mm).
   7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Set-Point Adjustment: Concealed.
      b. Set-Point Indication: Concealed.
      c. Thermometer: Concealed.
      d. Orientation: Vertical.
   8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. RTDs and Transmitters:
   1. Manufacturers:
      a. BEC Controls Corporation.
      b. MAMAC Systems, Inc.
      c. RDF Corporation.
      d. Or Approved Equal.
   2. Accuracy: Plus or minus 0.2 percent at calibration point.
   3. Wire: Twisted, shielded-pair cable.
   4. Insertion Elements in Ducts: Single point, 8 inches (200 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
   5. Averaging Elements in Ducts: 18 inches (460 mm) long, rigid; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (0.84 sq. m); length as required.

6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    a. Set-Point Adjustment: Concealed.
    b. Set-Point Indication: Concealed.
    c. Thermometer: Concealed.
    d. Orientation: Vertical.
8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

D. Dew Point Temperature Sensors: Bulk polymer sensor element.
1. Manufacturers:
    a. BEC Controls Corporation.
    b. General Eastern Instruments.
    c. MAMAC Systems, Inc.
    d. ROTRONIC Instrument Corp.
    e. TCS/Basys Controls.
    f. Vaisala.
2. Accuracy: plus/minus 3 deg F (1.5 deg C).
3. Room Sensor Range: 20 to 80 percent relative humidity.
4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    a. Set-Point Adjustment: Concealed.
    b. Set-Point Indication: Concealed.
    c. Thermometer: Concealed.
    d. Orientation: Vertical.
5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 22 to plus 185 deg F (minus 30 to plus 85 deg C).
7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Room Sensor Cover Construction: Manufacturer's standard locking covers.
1. Set-Point Adjustment: Concealed.
2. Set-Point Indication: Concealed.
3. Thermometer: Concealed.
4. Orientation: Vertical.

F. Room sensor accessories include the following:
1. Insulating Bases: For sensors located on exterior walls.
2. Guards: Locking, solid metal, ventilated.
3. Adjusting Key: As required for calibration and cover screws.

2.7 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.8 GAS DETECTION EQUIPMENT

A. Manufacturers:
   1. B. W. Technologies.
   2. CEA Instruments, Inc.
   3. Ebtron, Inc.
   4. Gems Sensors Inc.
   5. Greystone Energy Systems Inc.
   6. Honeywell International Inc.; Home & Building Control.
   7. INTEC Controls, Inc.
   8. I.T.M. Instruments Inc.
   9. MSA Canada Inc.
   10. QEL/Quatrosense Environmental Limited.
   11. Sauter Controls Corporation.
   12. Sensidyne, Inc.
   13. TSI Incorporated.
   14. Vaisala.
   15. Vulcain Inc.

B. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F (0 to 40 deg C); with 2 factory-calibrated alarm levels at 35 and 100 ppm.

C. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

2.9 THERMOSTATS

A. Manufacturers:
   1. Erie Controls.
   2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
   3. Honeywell.
   4. Sauter Controls Corporation.
   5. Tekmar Control Systems, Inc.
   6. Theben AG - Lumilite Control Technology, Inc.
   7. Approved equal.

B. Deadband: 5F.

C. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.
   1. Label switches "FAN ON-OFF".
   2. Mount on single electric switch box.

D. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
   1. Automatic switching from heating to cooling.
   2. Preferential rate control to minimize overshoot and deviation from set point.
   3. Set up for four separate temperatures per day.
   4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
   5. Short-cycle protection.
   6. Programming based on every day of week.
   7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
   8. Battery replacement without program loss.
   9. Thermostat display features include the following:
      a. Time of day.
      b. Actual room temperature.
      c. Programmed temperature.
      d. Programmed time.
      e. Duration of timed override.
      f. Day of week.

g. System mode indications include "heating," "off," "fan auto," and "fan on."
h. Minimum of four (4) spare input/output (IO) switches.

E. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.

F. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
2. Selector Switch: Integral, manual on-off-auto.

G. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

H. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

I. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.
1. Bulb Length: Minimum 20 feet (6 m).
2. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.

J. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.
   1. Bulb Length: Minimum 20 feet (6 m).
   2. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.

2.10 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
   1. Comply with requirements in Section 15058 "Common Motor Requirements for HVAC Equipment."
   2. 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.
   3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
   4. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
   5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
   6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   1. Manufacturers:
      a. Belimo Aircontrols (USA), Inc.
   2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
   3. Dampers: Size for running torque calculated as follows:
      a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
      b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
      c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
      d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
      e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.

f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 120-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C).
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).
12. Run Time: 12 seconds open, 5 seconds closed.

2.11 DAMPERS

A. Manufacturers:
   1. Air Balance Inc.
   2. Greenheck.
   3. Ruskin.
   4. United Enertech Corp.
   5. Vent Products Company, Inc.

B. Dampers: AMCA-rated, parallel and opposed-blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
   1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
   2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
   3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
   4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.13 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 16717 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) above the floor.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install guards on thermostats in the following locations:
   1. Entrances.
   2. Public areas.
   3. Where indicated.

E. Install automatic dampers according to Section 15820 "Duct Accessories."

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install refrigerant instrument wells, valves, and other accessories according to Section 15183 "Refrigerant Piping."

H. Install duct volume-control dampers according to Section 15815 "Metal Ducts" and Section 15816 "Nonmetal Ducts."

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 16130 "Raceways and Boxes."

B. Install building wire and cable according to Section 16120 "Conductors and Cables."

C. Install signal and communication cable according to Section 16717 "Communications Horizontal Cabling."
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.
   3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   4. Pressure test control air piping at 30 psig (207 kPa) or 1.5 times the operating pressure for 24 hours, with maximum 5-psig (35-kPa) loss.

5. Pressure test high-pressure control air piping at 150 psig (1034 kPa) and low-pressure control air piping at 30 psig (207 kPa) for 2 hours, with maximum 1-psig (7-kPa) loss.
6. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
7. Test each point through its full operating range to verify that safety and operating control set points are as required.
8. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
9. Test each system for compliance with sequence of operation.
10. Test software and hardware interlocks.

C. Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check system as follows:
    a. Verify that controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:
1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 1 Section "Demonstration and Training."

+ + END OF SECTION + +

SECTION 15950

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Balancing Air Systems:
      a. Constant-volume air systems.

1.3 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.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. 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.

D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC and NEBB.
   1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB.
   2. TAB Technician: Employee of the TAB contractor and who is certified by AABC or NEBB as a TAB technician.

B. TAB Conference: Meet with Architect on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
   1. Agenda Items:
      a. The Contract Documents examination report.
      b. The TAB plan.
      c. Coordination and cooperation of trades and subcontractors.
      d. Coordination of documentation and communication flow.

C. 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.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Architect/Engineer.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.

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 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 heat-transfer coils for correct piping connections and for clean and straight fins.

K. Examine system pumps to ensure absence of entrained air in the suction piping.

L. Examine operating safety interlocks and controls on HVAC equipment.

M. 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 AABC's "National Standards for Total System Balance", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" 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. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 15 Section "Duct Accessories."
   3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 15 Section "HVAC Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 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 "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 Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 15 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
   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 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.

3.7 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.8 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.

3.9 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
   1. Measure and record the operating speed, airflow, and static pressure of each fan.
   2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
   3. Check the refrigerant charge.
   4. Check the condition of filters.
   5. Check the condition of coils.
   6. Check the operation of the drain pan and condensate-drain trap.
   7. Check bearings and other lubricated parts for proper lubrication.
   8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
   1. New filters are installed.
   2. Coils are clean and fins combed.
   3. Drain pans are clean.
   4. Fans are clean.
   5. Bearings and other parts are properly lubricated.
   6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
   1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
   2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
   3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
   4. Balance each air outlet.

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 5 percent.
   2. Air Outlets and Inlets: Plus or minus 5 percent.

3.11 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare biweekly 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.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
      e. Manufacturer's serial number.
      f. Unit arrangement and class.
      g. Discharge arrangement.
      h. Sheave make, size in inches (mm), and bore.
      i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
      j. Number, make, and size of belts.
      k. Number, type, and size of filters.
   2. Motor Data:
      a. Motor make, and frame type and size.
      b. Horsepower and rpm.
      c. Volts, phase, and hertz.
      d. Full-load amperage and service factor.
      e. Sheave make, size in inches (mm), and bore.
      f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
   3. Test Data (Indicated and Actual Values):
      a. Total air flow rate in cfm (L/s).
      b. Total system static pressure in inches wg (Pa).
      c. Fan rpm.
      d. Discharge static pressure in inches wg (Pa).
      e. Filter static-pressure differential in inches wg (Pa).
      f. Preheat-coil static-pressure differential in inches wg (Pa).
      g. Cooling-coil static-pressure differential in inches wg (Pa).
      h. Heating-coil static-pressure differential in inches wg (Pa).
      i. Outdoor airflow in cfm (L/s).
      j. Return airflow in cfm (L/s).
      k. Outdoor-air damper position.
      l. Return-air damper position.
      m. Vortex damper position.

F. Apparatus-Coil Test Reports:
   1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
a. Air flow rate in cfm (L/s).
b. Average face velocity in fpm (m/s).
c. Air pressure drop in inches wg (Pa).
d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
h. Water flow rate in gpm (L/s).
i. Water pressure differential in feet of head or psig (kPa).
j. Entering-water temperature in deg F (deg C).
k. Leaving-water temperature in deg F (deg C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in deg F (deg C).
o. Inlet steam pressure in psig (kPa).

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
1. Unit Data:
a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h (kW).
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Air flow rate in cfm (L/s).
i. Face area in sq. ft. (sq. m).
j. Minimum face velocity in fpm (m/s).
2. Test Data (Indicated and Actual Values):
a. Heat output in Btu/h (kW).
b. Air flow rate in cfm (L/s).
c. Air velocity in fpm (m/s).
d. Entering-air temperature in deg F (deg C).
e. Leaving-air temperature in deg F (deg C).
f. Voltage at each connection.

g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
   1. Fan Data:
      a. System identification.
      b. Location.
      c. Make and type.
      d. Model number and size.
      e. Manufacturer's serial number.
      f. Arrangement and class.
      g. Sheave make, size in inches (mm), and bore.
      h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
   2. Motor Data:
      a. Motor make, and frame type and size.
      b. Horsepower and rpm.
      c. Volts, phase, and hertz.
      d. Full-load amperage and service factor.
      e. Sheave make, size in inches (mm), and bore.
      f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
      g. Number, make, and size of belts.
   3. Test Data (Indicated and Actual Values):
      a. Total airflow rate in cfm (L/s).
      b. Total system static pressure in inches wg (Pa).
      c. Fan rpm.
      d. Discharge static pressure in inches wg (Pa).
      e. Suction static pressure in inches wg (Pa).

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
   1. Report Data:
      a. System and air-handling-unit number.
      b. Location and zone.
      c. Traverse air temperature in deg F (deg C).
      d. Duct static pressure in inches wg (Pa).
      e. Duct size in inches (mm).
      f. Duct area in sq. ft. (sq. m).
      g. Indicated air flow rate in cfm (L/s).
      h. Indicated velocity in fpm (m/s).
      i. Actual air flow rate in cfm (L/s).
      j. Actual average velocity in fpm (m/s).
      k. Barometric pressure in psig (Pa).

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
   1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):
a. Air flow rate in cfm (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

K. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.13 INSPECTIONS

A. Initial Inspection:
1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:
a. Measure airflow of at least 5 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:
1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

+ + END OF SECTION + +

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SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 CONTRACTOR'S UNDERSTANDING

A. Contractors bidding work under this Contract shall read and understand Division Zero and Division 1 - General Requirements. If any discrepancies are discovered between the Basic Electrical Materials and Methods and General Requirements, the above mentioned documents shall overrule this section. The Basic Electrical Materials and Methods are intended as a supplement to the above mentioned documents.

B. The Contractor shall bid as outlined in the above mentioned Specifications and shall be governed by any alternates or unit prices called for in the form of proposal.

C. Each Contractor bidding on the work included in these Specifications shall view the building site and carefully examine the contract Drawings and Specifications, so that he/she may fully understand what is to be done, and to document existing conditions.

1.2 SCOPE OF WORK

A. Work included in this section of the Specifications shall include the furnishing of all labor, material, tools, approvals, utility connection fees, excavation, backfill, and other equipment necessary to install the electrical system as shown on the Contract Drawings and as specified herein.

B. It also includes installation and connection of all electrical utilization equipment included in this Contract but furnished by other contractors or suppliers.

C. It is the general intent that all motors shall be furnished with the particular object of equipment it drives, except where a new motor is to be provided for an item of existing equipment (a replacement motor), then it shall be provided under this Division of the Specifications.

D. The Contractor shall furnish and install all conduit, wire, disconnect switches and miscellaneous material to make all electrical connections to all items of utilization equipment or wiring devices except as otherwise specified.

E. Equipment connections shall be made with flexible or rigid conduit as required. Controllers for motors, disconnect switches, and all control, protective and signal

devices for motor circuits, except where such apparatus is furnished mounted and connected integrally with the motor driven equipment, shall be installed, connected and left in operating condition. The number and size of conductors between motors and control or protective apparatus shall be as required to obtain the operation described in these Specifications, and/or by the Contract Documents, and/or as shown in manufacturer furnished, Engineer reviewed Shop Drawings.

F. All devices and items of electrical equipment, including those shown on the Contract Drawings but not specifically mentioned in the Specifications or those mentioned in the Specifications but not shown on the Contract Drawings, are to be furnished under this section of the Specifications. Any such device or item of equipment, if not defined in quality, shall be equal to similar Equipment and/or devices specified herein.

G. All devices and items of equipment mentioned in this section of the Specifications whether electrical or not or whether furnished under this or other Division of the Specifications, shall be installed under this Division of the Specifications, unless specifically indicated otherwise.

H. Where wiring diagrams are not shown on the Contract Drawings, they are to be provided by the supplier of the equipment served and such diagrams shall be adhered to except as herein modified.

I. The following is a list of items that may not be defined clearly on the Contract Drawings or in other parts of these Specifications. The list is meant to be an aid to the Contractor and is not necessarily a complete list of all work to be performed under this Contract:
   1. Connect all motors and accessories furnished by equipment suppliers.
   2. Furnish, install, and connect all motor controls. Note some controls are furnished under Division 11, and installed by Electrical Contractor.
   3. Furnish, install, and connect lighting, indoor and outdoor.
   4. Furnish, install, and connect power and signal lines to all instrumentation equipment, and accessories.
   5. Furnish, install, and connect all electrical conduit, duct and cables.
   6. Furnish, install, and connect all telephone boxes, outlets, etc.
   7. Furnish, install, and connect all utility poles and hardware where specified on Contract Drawings.
   8. Furnish, install, and connect all power distribution equipment.
   9. Remove and properly dispose of all existing wiring and materials not to be reused in the renovated plant, as shown on the Contract Drawings.
   10. Furnish and install communications system cabling, connectors, outlets, etc.

J. All raceways and wiring shall be firestopped where required by code and/or indicated in the Contract Drawings, as specified in Section 07270.

1.3 SHOP DRAWINGS, DESCRIPTIVE LITERATURE, INSTALLATION, OPERATION AND MAINTENANCE INFORMATION

A. Shop Drawings including descriptive literature and/or installation, operation and maintenance instructions shall be submitted in the amount of 8 copies for this Division. All Shop Drawings shall be submitted in loose-leaf three-ring cardboard reinforced vinyl binders.

B. Shop Drawings shall be submitted on the following materials specified in this Division:
   1. Conduit - all types and sizes, including liquid-tight flexible.
   2. Boxes - all types and sizes.
   3. Coal tar epoxy paint.
   4. Wiring devices.
   5. Device plates.
   6. Supporting Devices/metal framing system (Strut type channel).
   7. Conduit fittings, expansion joints, support hardware.
   8. Motor control equipment - including individually mounted items.
   9. Power distribution equipment - including individually mounted items.
   10. Adjustable speed equipment and accessories.
   11. Miscellaneous spare parts and hardware.
   12. Wire - all types and sizes.
   13. Light fixtures - all types.
   14. Wire markers, signs and labels.
   15. Lightning/surge suppressors.
   16. Motors.
   17. Transformers.
   18. Standby power equipment and accessories.
   19 Security system.
   20. Electrical Studies and Calculations.
   21. Secondary Grounding.
   22. Medium Voltage Equipment.
   23. Fiber Optic Cables and associated equipment.
   24. Communication devices.
   25. Lighting Control System

C. The Engineer reserves the right to make modifications to motor control and power distribution equipment ratings after Shop Drawing review, if the Shop Drawings are submitted prematurely (prematurely meaning submitted before all utilization equipment has been reviewed and accepted). Cost of modifications shall be the Contractor's responsibility.

1.4 SYMBOLS AND ABBREVIATIONS

A. The symbols and abbreviations generally follow standard electrical and architectural practice, however, exceptions to this shall be as shown on the

Contract Drawings.

1.5 COORDINATION WITH OTHER TRADES

A. The Contractor shall coordinate the electrical work with that of other trades to ensure proper final location of all electrical equipment and/or connections. The Contractor shall verify door swings to see that light switches are located properly.

1.6 CODES

A. The minimum standard for all work shall be the latest revision of the Kentucky Building Code (KBC) and the National Electrical Code (NEC). Whenever and wherever state and/or local laws or ordinances and/or regulations and/or the Engineer's design require a higher standard that the current NEC or KBC, then these laws and/or regulations and/or the design shall be followed.

B. Following is a list of other applicable Standards or Codes:

1.	Kentucky Building Code	KBC
2.	National Electrical Code	NEC
3.	National Electrical Safety Code	NESC
4.	Underwriters Laboratories, Inc.	UL
5.	Factory Mutual System	FM
6.	National Fire Protection Association	NFPA
7.	National Electrical Manufacturers Association	NEMA
8.	Occupational Safety and Health Administration	OSHA
9.	Insulated Cable Engineers Association, Inc.	ICEA
10.	Illuminating Engineering Society of North America	IES
11.	Instrument Society of America	ISA
12.	Institute of Electrical and Electronic Engineers, Inc.	IEEE
13.	Certified Ballast Manufacturers Association	CBM
14.	American National Standards Institute, Inc.	ANSI
15.	Anti-Friction Bearing Manufacturers Association, Inc.	AFBMA
16.	Joint Industry Council	JIC
17.	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.	ASHRAE
18.	Federal Communications Commission	FCC
19.	American Society for Testing and Materials	ASTM
20.	American Wood Preservers Association	AWPA
21.	Rural Electrification Association	REA

1.7 INSPECTIONS AND PERMITS

A. Inspection of the electrical system on all construction projects is required. If the local government has appointed a state licensed inspector, the Contractor shall be required to use that person to perform the inspections. If a locally mandated inspector does not exist, the Contractor shall select and hire a state licensed

inspector, who has jurisdiction before any work is concealed. The Contractor shall notify the electrical inspector in writing, immediately upon notice to proceed, and a copy of the notice shall be submitted to the Engineer.

B. At the time of completion of the project, there shall be furnished to the Owner a certificate of compliance, from the agency having jurisdiction pursuant to all electrical work performed. The Engineer shall also receive a photostatic copy.

C. All costs incurred by the Contractor to execute the above mentioned requirements shall be paid by the Contractor at no extra cost to the Owner.

D. All permits necessary for the complete electrical system shall be obtained by the Contractor from the authorities governing such work. For further information, see Division 1.

1.8 STORAGE

A. All work, equipment, and materials shall be protected against dirt, water, or other injury during the period of construction.

B. Sensitive electrical equipment such as light fixtures, motor starters, controls, and panelboards, delivered to the job site, shall be protected against injury or corrosion due to atmospheric conditions or physical damage by other means. Protection is interpreted to mean that equipment shall be stored under roof, in a structure properly heated in cold weather and ventilated in hot weather. Provision shall be made to control the humidity in the storage area to 50 percent relative. The stored equipment shall be inspected periodically, and if it is found that the protection is inadequate, further protective measures shall be employed. Electrical equipment other than boxes and conduit shall not be installed until the structure is under roof with doors and windows installed.

C. No light fixtures or device plates shall be hung or installed until after painting is completed; however, temporary lighting shall be provided by the Contractor.

1.9 MATERIALS

A. All materials used shall be new and at least meet the minimum standards as established by the NEC and/or National Electrical Manufacturers Association (NEMA). All materials shall be UL listed for the application, where a listing exists. Additional requirements are found in Division 1. All equipment shall meet applicable FCC requirements and restrictions.

B. The material and equipment described herein has been specified according to a particular trade name or make to set quality standards. However, each Contractor has the right to substitute other material and equipment in lieu of that specified, other than those specifically mentioned at matching or for standardization,

providing such material and equipment meets all of the requirements of those specified and is accepted, in writing by the Engineer.

C. The reuse of salvaged electrical equipment and/or wiring shall not be permitted unless specified herein or indicated on the Contract Drawings.

D. All salvaged or abandoned electrical materials shall become the property of the Owner. Any removed equipment which the Owner does not want shall be removed from the job site upon completion of the project, unless otherwise noted on the Contract Drawings or specified herein.

1.10 ERRORS, CORRECTIONS, AND/OR OMISSIONS

A. Should a piece of utilization equipment be supplied of a different size or horsepower than shown on the Contract Drawings, the Contractor shall be responsible for installing the proper size wiring, conduit, starters, circuit breakers, etc., for proper operation of that unit and the complete electrical system at no extra cost to the Owner.

B. It is the intent of these Specifications to provide for an electrical system installation complete in every respect, to operate in the manner and under conditions as shown in these Specifications and on the Contract Drawings. The Contractor shall notify the Engineer, in writing, of any omission or error at least 10 days prior to opening of bids. In the event of the Contractor's failure to give such notice, he/she may be required to correct work and/or furnish items omitted without additional cost. Further requirements on this subject may be found in the General Requirements, Division 1.

C. Necessary changes or revisions in electrical work to meet any code or power company requirement shall be made by the Contractor without additional charge to the Owner.

1.11 GUARANTEES AND WARRANTIES

A. The Contractor shall guarantee all work including equipment, materials, and workmanship. This guarantee shall be against all defects of any of the above and shall run for a period of 1 year from the date of acceptance of the work, concurrent with the one year guarantee period designated for the general construction contract under which electrical work is performed. Date of acceptance shall be considered to be the date on which all "punch list" items are completed ("punch list" is defined to be the written listing of work that is incomplete or deficient that must be finished or replaced/repaired before the Contractor receives final payment).

B. Repair and maintenance for the guarantee period is the responsibility of the Contractor and shall include all repairs and maintenance other than that which is

considered as routine. (That is oiling, greasing, etc.) The Engineer shall be the judge of what shall be considered as routine maintenance.

C. Where defects (and damage to other Work resulting therefrom) have been corrected or removed and replaced under this Paragraph 1.11, the guarantee with respect to such Work will be extended for an additional period of one year after such correction or removal and replacement has been satisfactory completed and accepted by the Engineer/Owner.

D. Lamps shall bear the manufacturer's warranty.

1.12 TESTING

A. After the wiring system is complete, and at such time as the Engineer may direct, the Contractor shall conduct an operating test for acceptance. The equipment shall be demonstrated to operate in accordance with the requirements of these Specifications and the Contract Drawings. The test shall be performed in the presence of the Engineer or his authorized representative. The Contractor shall furnish all instruments and personnel required for the tests, as well as the necessary electrical power.

B. Before energizing the system, the Contractor shall check all connections and set all relays and instruments for proper operation. He shall obtain all necessary clearances, approvals, and instructions from the serving utility company and/or equipment manufacturers prior to placing power on the equipment.

C. Tests may be requested by the Engineer to determine integrity of insulation on wiring circuits selected by the Engineer at random.

D. Cost of utilities for testing done prior to beneficial occupancy by the Owner shall be borne by the Contractor.

1.13 CLEANUP

A. Cleanup shall be completed as soon as possible after the electrical installation is complete. All light fixtures, outlets, switches, starters, motor control centers, disconnect switches and other electrical equipment shall be free of shipping tags, stickers, etc. All painted equipment shall be left free of scratches or other blemishes, such as splattered or blistered paint, etc. All light fixture diffusers shall be clean and the interior of all motor controls, etc., shall be free of dust, dirt, wire strippings, etc. Surplus material, rubbish and equipment resulting from the work shall be removed from the job site by the Contractor upon completion of the work.

B. During construction, cover all Owner equipment and furnishings subject to mechanical damage or contamination in any way.

1.14 CUTTING AND PATCHING

A. Cutting and patching shall be held to an absolute minimum and such work shall be done only under the direction of the Engineer or Owner. The Contractor shall be responsible for and shall pay for all openings that may be required in the floors or walls, and he shall be responsible for putting said surfaces back in their original condition. Every attempt shall be made to avoid cutting reinforcing steel bars when an opening is required in a reinforced concrete wall or floor slab.

1.15 EXCAVATION AND BACKFILL

A. Excavation
   1. Excavation for conduits shall be of sufficient width to allow for proper jointing, alignment and encasement of the type conduit used. Conduit shall be laid in straight lines between pull boxes and/or structures unless otherwise noted on the Contract Drawings. The cost of solid rock excavation shall be included in the lump sum bid with no extra pay allowed (unclassified).

B. Backfill
   1. Backfill shall be hand placed, loose granular earth for a height of 6 inches above the top of the largest conduit. This material shall be free of rocks over 2 inches in diameter. Above this, large rocks may be included but must be mixed with sufficient earth to fill all voids.

1.16 SLEEVES, CHASES AND OPENINGS

A. Sleeves shall be required at all points where exposed conduits pass through new concrete walls, slabs, or masonry walls. Sleeves that must be installed below grade, or where subject to high water conditions, must be installed watertight.

B. Wiring chases shall be provided where shown on the Contract Drawings. The Contractor shall have the option of installing chases below surface mounted panelboards provided all structural requirements are met.

C. It is the Contractor's responsibility to leave openings to allow installation of the complete, operational electrical system. Openings required but not left shall be cut as outlined under cutting and patching. The Contractor shall coordinate all holes and other openings with necessary diameters for proper firestopping.

1.17 POWER COMPANY COORDINATION

A. The Contractor is responsible for coordinating all activities onsite by the power company.

B. All power company metering equipment shall be electrically located "upstream" of any manual/automatic transfer equipment on projects requiring onsite

emergency power generation equipment.

C. Any special provisions required by the serving electrical utility shall be as outlined on the Contract Drawings or as advised by the utility at the time of construction, and work required by these special provisions shall be executed with no extra cost to the Owner.

1.18 TEMPORARY ELECTRICAL POWER

A. The Contractor shall be responsible for providing temporary electrical power as required during the course of construction and shall remove the temporary service equipment when no longer required. Temporary power is also addressed in Division 1.

1.19 OVERCURRENT PROTECTION

A. Circuit breakers or fused switches shall be the size and type as written herein and shown on the Contract Drawings. Any additional overcurrent protection required to maintain an equipment listing by an authority having jurisdiction shall be installed by the Contractor at no extra cost to the Owner.

B. The Contractor shall submit to the Engineer actual nameplate data from motors shipped to the site, stating motor identification as well as characteristics. Overload relay thermal unit selection tables shall accompany the motor data. The Engineer will select thermal unit sizes from this data for use by the Contractor in ordering proper thermal units.

1.20 TRAINING

A. All manufacturers supplying equipment for this division shall provide the Owner's operations staff with training in the operation and maintenance on the equipment being furnished. The training shall be conducted at the project site by a qualified representative of the manufacturer.

B. The cost of this training shall be included in the bid price.

C. The required training shall consist of both classroom and hands-on situation. Classroom training shall include instruction on how the equipment works, its relationship to all accessories and other related units, detailed review of shop drawings, detailed presentation of written O & M instructions, troubleshooting and record-keeping recommendations. Hands-on-training shall include a review of the manufacturer's O & M instructions, check out of each operator to identifying key elements of the equipment, tear down as appropriate, calibration, adjustment, greasing and oiling points, and operating manipulations of all electrical and mechanical controls.

D. The training shall be scheduled through the Contractor with the Owner. The timing of the training shall closely coincide with startup of the equipment, but no

training shall be conducted until the equipment is operational.

E. The minimum number of hours to be provided by manufacturers supplying equipment on this project shall be in accordance with the following table:

Item	Training Hours	
	Classroom	Hands-on
Standby Power System & Accessories	4	4
Medium Voltage Motor Controllers	2	2
Variable Speed Systems	3	3
Security System	1	1

F. At least 60 days prior to the training the manufacturer shall submit through the Contractor to the Engineer an outline of the training proposed for the Engineer's review and concurrence.

G. The Owner reserves the right to videotape all training sessions.

1.21 AS BUILT DRAWINGS

A. The Contractor shall maintain 1 set of the Contract Drawings on the job in good condition for examination at all times. The Contractor's qualified representative shall enter upon these drawings, from day to day, the actual "as-built" record of construction and/or alteration progress. Entries and notes shall be made in a neat and legible manner and these drawings delivered to the Engineer after completion of the construction, for use in preparation of Record Drawings.

1.22 MAINTAINING CONTINUOUS ELECTRICAL SYSTEM AND SERVICE

A. Existing service(s) continuity shall be maintained at all times. In no way shall the installation and/or alteration of the electrical work interfere with or stop the normal operation of the existing facilities, except where prior arrangements have been made. If the Contractor needs to shut down normal building power for any reason or duration, a 2 week notice shall be given to the Owner and the Owner shall approve the outage.

B. Any scheduled power outage shall be performed between midnight and 8 AM. If additional days are required for a power outage, the additional day(s) must be scheduled a minimum of 24 hours after the prior outage. The plant shall not be shut down more than once during a 24 hour period.

C. When additions and taps to existing service(s) require electrical outages of duration in excess of a few minutes, arrangements shall be made in advance for such outages. All outages shall be held to an acceptable minimum with none exceeding 8 hours continuous duration. If necessary, cuts shall be performed on

premium time. If performed at night, requiring a general outage, the Contractor shall furnish an auxiliary source of light and power as required. Under no circumstances shall an electrical outage of any duration be initiated until the Owner and Engineer have concurred, and as far as possible in advance.

1.23 GROUNDING AND BONDING

A. All metallic conduit, cabinets, equipment, and service shall be grounded in accordance with the latest issue of the National Electrical Code. All supporting framework and other metal or metal clad equipment or materials which are in contact with electrical conduit, cable and/or enclosures, shall be properly grounded to meet the code requirements.

1.24 RELATED SPECIFICATION DIVISIONS

A. The following divisions contain Specifications on utilization equipment, equipment accessories, and procedures related to execution of the electrical work, and are included here for the Contractor's information. Bids shall still be based on complete Contract Documents.

Division 0	-	Bidding Requirements, Contract Forms, and Conditions of the Contract
Division 1	-	General Requirements
Division 2	-	Sitework
Division 3	-	Concrete
Division 8	-	Doors and Windows
Division 9	-	Finishes
Division 10	-	Specialties
Division 11	-	Equipment
Division 12	-	Furnishings
Division 13	-	Special Construction
Division 15	-	Mechanical

1.25 SERVICE ENTRANCE

A. Conductors and terminations for service entrances shall be furnished and installed by the Contractor. Voltage, phase, and number of wires shall be as shown on the Drawings. Clearances for overhead entrance wires shall be per the Power Company, NEC, and NESC requirements.

B. Any details not shown on the Drawings or written in the Specifications pertaining to the service entrance shall be per power company requirements. It is the Contractor's responsibility to contact the utility prior to bidding and obtain any special requirements or costs they will be imposing. Those costs shall be included in the bid.

1.26 CONTRACTOR LICENSING

A. The Contractor performing the electrical work on this project shall be locally licensed, if required by local law or ordinance. If the Contractor has passed the State test, it may not be necessary to meet local testing requirements. It shall be the Contractor's responsibility to investigate these requirements and comply with same.

1.27 ANCHORING/MOUNTING

A. Electrical conduits and/or equipment shall be rigidly supported. Anchors used shall be metallic expansion type, or if appropriate to prevent spalling concrete, epoxy set type. Plastic or explosive type anchors are prohibited.

B. The Contractor shall ensure that all supports are consistent with the KBC requirements in regard to Seismic Zoning.

1.28 ELECTRICAL COMPONENT MOUNTING HEIGHTS

A. Unless otherwise indicated, mounting height for components shall be as defined herein. In cases of conflicts with architectural or structural aspects, the components may be relocated. If an indicated height conflicts with a code requirement, the code shall govern.

B. Mounting heights are given from finished floor elevation to the centerline of the component, unless otherwise noted.

	Component	**Height**	**Comments**
1.	Wall type light switch	4'-0"	To top of box
2.	Low wall outlet	16"	To bottom
3.	Medium height wall outlet	4'-0"	
4.	Wall type buzzers, horns, etc.	8'-0" Max.	Top 2" below ceiling
5.	Wall type exit signs	8'-0" Max.	Top of sign 2" below ceiling
6.	Push-button or control stations	4'-0"	
7.	Top of panelboards or control panels	6'-6"	Maximum (except for handicapped areas)
8.	Top of telephone cabinets	6'-6"	Maximum
9.	Top of switch handle on motor control center	6'-6"	Maximum
10.	Top of local motor controller	6'-0"	Maximum
11.	Top of local disconnect switch	6'-0"	Maximum
12.	Wall mount exterior light fixtures	8'-0"	Unless otherwise shown on Contract Drawings

In situations where there appears to be a conflict with Americans with Disabilities

Act (ADA) legislation, utilize the ADA requirements herein.

1.29 RECEIPTS

A. Some sections of the Specifications call for equipment, materials, accessories, etc. to be provided and "turned over to the Owner" or like requirements. The Contractor shall obtain a receipt for each item turned over, signed by the Owner or his representative. A copy of this receipt shall be transmitted to the Engineer.

B. When a question arises concerning whether items have been turned over to the Owner, and there is no signed receipt, it may be assumed that the items were not provided.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

Not Applicable.

+ + END OF SECTION + +

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SECTION 16060

SECONDARY GROUNDING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Grounding shall be done in accordance with the NEC, as described in these Specifications, and as shown on the Contract Documents.

B. The Contractor shall provide shop drawings illustrating all grounding electrode routing layouts, ground grids and connections.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Grounding equipment shall be Cadweld, ITT Blackburn, ITT Weaver, Copperweld Bimetallics Group, Cathodic Engineering Equipment Co., or equal.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Grounding shall utilize a supplemental driven ground rod system in a bed to achieve the design ground resistance.

B. The ground system shall be continuous with all structures on a common ground. This can be accomplished by bonding all conduits together and bonding to the ground bus at main circuit breaker. Bonding jumpers shall be required at all pull boxes, and at all motor casings. A separate grounding conductor shall be pulled in all conduits in addition to wire counts shown on Drawings.

C. Ground rods shall be 3/4" x 10'-0" copper clad type. Where multiple rods are driven, they shall be separated by at least 10 feet to assure maximum effect.

D. Ground resistance between ground and absolute earth shall not exceed 5 ohms.

E. All grounding and grounding electrode systems shall be as required by the NEC as for types of electrodes utilized and sizing of grounding conductor to service equipment from the electrode system. These shall include footer rebar, buried metal water pipe, buried bare copper conductor, etc.

F. All grounding electrode system connections shall be made using exothermic

welds, Cadweld, or equal. No splices are allowed in the grounding electrode conductor.

G. Should ground rods be impractical for use due to rocky conditions, then grounding electrode plates may be used after acceptance by the Engineer on a case by case basis.

3.2 FIELD QUALITY CONTROL

A. Testing
   1. The Contractor shall be required to provide all labor, tools, instruments, and materials as necessary to perform testing of the grounding electrode system. Results shall be submitted in writing to the Engineer. The testing shall be done to determine the effectiveness of the selected grounding scheme and to provide conformation with resistance specified (5 ohms maximum).
   2. The testing should be done using a fall-of-potential method test at the point of grounding electrode conductor connection to main power distribution equipment and at each separately derived system or MCC. The test shall be performed no sooner than 48 hours after a rainfall event.
   3. The written report should contain the following information:
      a. Type of ground scheme used, i.e., building steel, driven rod, mat, etc.
      b. Type of instrument used.
         1) Manufacturer
         2) Model Number
         3) Confirm fall-of-potential test
         4) *Serial Number
         5) *Where instrument was obtained
            * These 2 items are required so that the same instrument may be utilized should reproduction of the test be necessary due to unsatisfactory readings/instrument miscalibration.
      c. Ground resistance readings obtained at various test distances.
      d. Ground resistance/distance curve.
      e. Value of Grounding Electrode Resistance at knee of curve.
      f. Sketch showing setup of instrumentation and location of grounding electrode and test probes.
      g. Proposed method to achieve the specified resistance, should an unacceptable reading be obtained.
      h. Ground resistance readings obtained (if applicable) after modifications incorporated.

3.3 GROUND ENHANCEMENT MATERIAL

A. Where indicated on the Drawings or as deemed necessary by the Contractor to achieve design grounding electrode system resistance, a ground enhancement material shall be utilized, in accordance with manufacturer's recommendations.

B. The ground enhancement material must be permanent and maintenance free (no recharging with salts or chemicals which may be corrosive) and maintain its earth resistance for the life of the system. It must set up firmly and not dissolve or decompose, or otherwise pollute the soil or local water table. The material shall be capable of being applied dry or in a slurry form, and shall reduce resistance by at least 40 percent.

C. Basic components of this material shall be carbon, hydraulic cements, and hydrous aluminum silicates. Minimum 4-inch diameter holes shall be used with ground rod installations, with depth 6" shorter than length of rod, completely filled with the material. Trenches for grounding electrode conductor shall also utilize this material the full length from electrode to building, in accordance with manufacturer installation recommendations, except trench depth shall allow buried conductor to be at least 2'-6" deep.

D. Ground enhancement material shall be GEM by Erico Products, Powerfill by Cathodic Engineering Equipment Company, or equal.

+ + END OF SECTION + +

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SECTION 16070

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. All electric equipment shall be rigidly mounted, and installed using supporting devices as indicated on the Contract Drawings, as required by the work, and described herein.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. "Kindorf," "Unistrut," or equal.

2.2 MATERIALS

A. All mounting brackets and strut used outside shall be aluminum. Fasteners used to mount equipment outside shall be stainless steel. The only exception to the above shall be anchor bolts for area lightpoles which shall be allowed to have galvanized threads and galvanized nuts.

B. All mounting brackets and strut used inside shall be galvanized or aluminum. If galvanized is used, then the cut ends shall be cold galvanized and painted. Fasteners used inside to mount equipment into concrete shall also be stainless steel. Ungalvanized strut is prohibited.

C. Stainless steel (non-magnetic) or fiberglass resin strut shall be used in chemical areas and areas exposed to chlorine gas.

PART 3 - EXECUTION

3.1 ANCHORING CABINETRY

A. All free standing equipment shall be anchored to its foundation using expansion bolts of the size and number recommended by the equipment manufacturer.

3.2 SEISMIC CONSIDERATIONS

A. Where indicated, seismic restraints shall be provided for electrical equipment.

+ + END OF SECTION + +

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SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 EQUIPMENT LABELING

A. All starters, feeder units in panelboards, switchboards, disconnects, instruments, etc. shall be marked to indicate the motor, outlet, circuit they control, or variable monitored. Marking is to be done with engraved laminated nameplates and shall bear the designation shown on the Contract Drawings where this information is given. Nameplates shall be fastened to equipment with stainless steel screws, minimum of one each side. In no way shall the installation of mounting screws void the NEMA enclosure rating of the equipment in which they are installed. If there are more than one identical unit, they shall be given consecutive numbers or other descriptions as designated by the Engineer. Nameplate background color shall be white, with black engraved letters, unless otherwise noted.

B. Branch circuits in lighting panels shall be typed on a card suitable for the card frame furnished with the panel. The card shall bear the panel designation listed on the Contract Drawings where this information is given, as well as indicate what each circuit controls.

C. Individual wall mounted starters, panelboards, and disconnect switch shall be labeled with vinyl self-adhesive signs that warn of “High Voltage” (state the specific voltage) and Arc Flash. Main service entrance conduits to a building, where exposed, shall be labeled with the voltage of the service they carry. Other major equipment such as transformers, transfer switches, generator sets, pump control panels, etc., shall be labeled as such. The type of labels to be used shall have orange as the basic color to conform with OSHA requirements, letters shall be black. The labels shall be of proper size to fit flatly on the surface of the enclosure to make for a neat appearance and not interfere with the operating function of the device it is attached to. These labels shall be as manufactured by the Brady Identification Systems Division, Safety Sign Company, Westline Products Company, or equal.

D. Furnish and install “Authorized Personnel Only” signs by doors into all power distribution equipment rooms/buildings. Furnish and install other signs as indicated on the Contract Drawings.

PART 2 - PRODUCTS

2.1 CONDUIT LABELS:

A. Products and Manufacturers: Provide one of the following:
   1. B-915-xxxxx by Brady.
   2. Or equal.

B. Shall be pre-tensioned acrylic/vinyl construction coiled to completely encircle conduit for conduit up through five-inch diameter, or pre-molded to conform to circumference of conduit six-inch diameter and larger.

C. Attach strap-on style for six-inch diameter conduit with stainless steel springs.

D. Shall be blank for use with custom printed labels.

E. Custom Labels:
   1. Shall have black lettering on yellow background.
   2. Shall not contain abbreviations in legend.
   3. Shall be custom printed on continuous tape with permanent adhesive using thermal printer specified below.

2.2 WIRE IDENTIFICATION:

A. Heat Shrinkable Wire and Cable Labeling System:
   1. White heat-shrinkable irradiated polyolefin shrink-on sleeves. Labels shall be thermal printed. Labels shall be at least two inches wide.
   2. Products and Manufacturers: Provide one of the following:
      a. B-341 PS-xxx-2W by Brady.
      b. Or equal.

B. Wrap-Around Wire and Cable Labeling System:
   1. Self-laminating white/transparent self extinguishing vinyl strips. Length shall be sufficient to provide at least 2.5 wraps. Labels shall be thermally printed and at least two inches wide.
   2. Products and Manufacturers: Provide one of the following:
      a. THT-XX-427 by Brady.
      b. Or equal.

2.3 DETECTABLE UNDERGROUND WARNING TAPE:

A. Material: Polyethylene or polyester with detectable metal core and polyester underlaminate.

B. Width: Two inches.

C. Color and Labeling: Yellow or red with permanently imprinted black letters: “CAUTION – Buried Electric Service” or “Buried High Voltage Cable”, repeated continuously over full length of tape.

D. Products and Manufacturers: Provide one of the following:

1. Indentoline by Brady.
2. Or equal.

2.4 THERMAL PRINTING SYSTEM:

A. Utilize thermal transfer process to provide non-smearing labels and markers.

B. Wire and Cable Markers:
   1. Portable, Products and Manufacturers: Provide one of the following:
      a. TLS2200 by Brady.
      b. Or equal.
   2. Desktop, Products and Manufacturers: Provide one of the following:
      a. 200M by Brady.
      b. Or equal.

C. Cable Markers:
   1. Portable, Products and Manufacturers: Provide one of the following:
      a. Handimark by Brady.
      b. Or equal.
   2. Desktop, Products and Manufacturers: Provide one of the following:
      a. Labelizer PLUS by Brady.
      b. Or equal.

2.5 GENERATOR SYSTEM WARNING SIGNS:

A. Generator warning signs shall be labeled in accordance with NEC Article 700, NEC Article 701, or NEC Article 702.

B. Material, Colors, Letters: Plastic with white letters on a red background. Letters shall be minimum height of 3/8 inch.

C. Attachment: Use stainless steel self-tapping screws.

D. Location warning sign shall read, "WARNING – THIS SITE EQUIPPED WITH A DIESEL DRIVEN STAND-BY GENERATOR LOCATED IN AN ADJACENT ROOM".

E. Generator ground warning sign shall read, "WARNING – GENERATOR GROUNDED CIRCUIT CONDUCTOR IS CONNECTED TO THE GROUNDING ELECTRODE CONDUCTOR IN THIS ENCLOSURE. DO NOT OPERATE GENERATOR WHILE EITHER CONDUCTOR IS DISCONNECTED TO AVOID SEVERE SHOCK HAZARD AND POSSIBLE EQUIPMENT DAMAGE."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide electrical identification in accordance with manufacturer recommendations and as required for proper identification of equipment and materials.

B. Engraved Identification Devices (Nameplates and Legend Plates):
   1. Unless otherwise specified, attach permanent nameplates with permanent adhesive and with 3/16-inch diameter, round head, stainless steel machine screws into drilled and tapped holes.
   2. Provide nameplate with 1.5-inch letters to identify each console, cabinet, panel, or enclosure as shown or indicated.
   3. Provide nameplates for field-mounted motor starters, disconnect switches, manual starter switches, pushbutton stations, and similar equipment operating components, which shall describe motor or equipment function and circuit number.
   4. Provide nameplates with 1/2-inch letters to identify each junction and terminal box shown or indicated.
   5. On switchgear, provide nameplates for each main and feeder circuit including control fuses, and for each indicating light and instrument.
      a. Provide nameplate with 1.5-inch letters giving switchgear designation, voltage rating, ampere rating, short circuit rating, manufacturer's name, general order number, and item number.
      b. Identify individual door for each compartment with nameplate giving item designation and circuit number.
   6. Motor Control Centers:
      a. Provide nameplate with 1.5-inch letters with motor control center designation.
      b. Identify individual door for each unit compartment with nameplate identifying controlled equipment.
   7. Except conduit, all electrical appurtenances including lighting panels, convenience outlets, fixtures, and lighting switches, shall be provided with nameplates indicating appropriate circuit breaker number(s).
   8. Push Buttons:
      a. Provide legend plates for identification of functions.
      b. Provide nameplates for identification of controlled equipment.
      c. Provide red buttons for stop function.
      d. Provide black buttons for other functions.
   9. Pilot Lights:
      a. Provide legend plates for identification of functions.
      b. Provide nameplates for identification of controlled equipment.
      c. Shall have lens colors as shown or indicated. Where no color is indicated, provide the following lens colors:

Color	Legend
Green	Running, Open
Red	Stopped, Closed
Amber	Alarm
Blue	Power
White	Status

10. Selector Switches:
    a. Provide legend plates for identification of functions.
    b. Provide nameplates for identification of controlled equipment.
11. Panel Mounted Instruments:
    a. Provide nameplates for identification of function.
12. Interiors of Cabinets, Consoles, Panels, Terminal Boxes, and Other Enclosures:
    a. Provide nameplates for identification.
    b. Provide each item inside cabinet, console, panel, terminal box, or enclosure with laminated plastic nameplate as shown on approved Shop Drawings and submittals. Install nameplates with adhesive.
    c. Interior items requiring nameplates include:
        1) Terminal blocks and strips.
        2) Bus bars.
        3) Relays.
        4) Rear of face-mounted items.
        5) Rear of door-mounted items.
        6) Interior mounted items that require identification when mounted externally.
    d. Circuit Breaker Directory:
        1) Provide engraved laminated plastic directory listing function and load controlled for each circuit breaker within panel used for power distribution.
13. Re-label existing equipment whose designation have changed.

C. Safety Signs and Voltage Markers:
1. Provide safety signs and voltage markers on and around electrical equipment as shown or indicated.
    a. Install rigid safety signs using stainless steel fasteners.
    b. Clean surfaces before applying pressure-sensitive signs and markers.
2. Install high voltage safety signs on all equipment doors providing access to uninsulated conductors, including terminal devices, greater than 600 volts.
3. Provide cable tray safety signs on both sides of cable trays at maximum intervals of 20 feet. Install signs on side rails of tray as acceptable to ENGINEER.
    a. Label cable trays that contain conductors greater than 600 volts with cable tray safety signs.
    b. Cable trays that contain conductors greater than 208 volts and less than 600 volts shall be labeled with low voltage safety signs.

c. Cable trays that contain conductors of 120/208 volts shall be labeled with low voltage markers.
d. Do not label cable trays that contain only instrument signal cables.
e. Label cable trays that contain intrinsically safe wiring or cables in accordance with NEC Article 504.

4. Install low voltage safety signs on equipment doors that provide access to uninsulated 480-volt conductors, including terminal devices.
5. Install low voltage markers on each terminal box, safety disconnect switch, and panelboard installed, modified, or relocated as part of the Work and containing 120/208 volt conductors.

D. Voltage System Identification Directories
1. Provide voltage system identification directories as required by NEC Article 210 and NEC Article 215.
2. Provide in each electrical room voltage system identification directory mounted on wall or door at each entrance to room.
3. For panelboards, switchboards, motor control centers, and other branch circuit or feeder distribution equipment that are not located in electrical rooms, provide voltage system identification directory mounted on equipment.
a. Directories shall be affixed using epoxy glue. Screws or bolts shall not penetrate equipment enclosures.
b. Directories shall be readily visible and not obscure labels and other markings on equipment.

E. Arc-flash Safety Signs:
1. Provide arc-flash safety signs as required by NEC Article 110.
2. Provide signs for switchboards, panelboards, motor control centers, and industrial control panels. Provide signs for control panels that contain 480 volt equipment.

F. Conduit Labels:
1. Provide conduits with conduit labels unless otherwise shown or indicated.
2. Do not label flexible conduit.
3. Do not label exposed single conduit runs of less than 25 feet between local disconnect switches and their associated equipment.
4. Conduit labels shall indicate the following information:
a. Contract Number: Alphanumeric, three or four digits, as applicable.
b. Conduit Number: Alphanumeric as shown on the Drawings, as assigned by CONTRACTOR for unlabelled conduits, and in accordance with approved submittals.
5. Conduits that contain intrinsically safe wiring shall have an additional pipe marker provided that has blue letters on white background and reads, “INTRINSICALLY SAFE WIRING”.
a. Install intrinsically safe pipe markers in accordance with NEC Article 504 along entire installation. Spacing between labels shall not exceed 25 feet.

6. Provide conduit labels at the following locations:
    a. Where each conduit enters and exits walls, ceilings, floors, or slabs.
    b. Where conduit enters or exits boxes, cabinets, consoles, panels, or enclosures, except pull boxes and conduit bodies used for pull boxes.
    c. At maximum intervals of 50 feet along length of conduit.
7. Orient conduit labels to be readable.

G. Wire and Cable Identification:
1. Color-coding of insulated conductors shall comply with Section 26 05 19, Low Voltage Electrical Power Conductors and Cables, Section 26 05 13.23, 15KV Cable, and Section 26 05 13.26, 5KV Cable.
2. Use heat-shrinkable wire labels where wire or cable is terminated. Use wrap-around labels where wire or cable is to be labeled but is not terminated.
3. Do not provide labels for the following:
    a. Bare (uninsulated) conductors, unless otherwise shown or indicated as labeled.
4. Provide wire and cable labels for the following:
    a. New, rerouted, or revised wire or cable.
    b. Insulated conductors.
    c. Wire and cable terminations:
        1) Wire labels shall be applied between 1/2-inch and one inch of completed termination
        2) Apply cable labels between 1/2-inch and one inch of cable breakout into individual conductors.
            a) Label individual conductors in a cable after breakout as specified for wires.
    d. Wire or cable exiting cabinets, consoles, panels, terminal boxes, and enclosures.
        1) Label wires or cables within two inches of entrance to conduit.
    e. Wire or cable in junction boxes and pull boxes
        1) Label wires or cables within two inches of entrance to conduit.
    f. Wire and cable installed in cable tray.
        1) Wire and cable shall have labels at maximum intervals of 20 feet.
    g. Wire and cable installed without termination in electrical manholes.
        1) Wire and cable shall have wrap-around labels applied within one foot of exiting manhole.
5. Wire and Cable Identification System:
    a. Wire and cable labels shall be imprinted with an identifying designator.
        1) Wire and cable extending between two devices or items and that does not undergo a change of function shall be identified by a single unique designator as specified below.
    b. Field Wiring:
        1) Wire or cable designator shall consist of:
            a) Three left-most characters shall consist of the Contract number under which wiring or cable was installed.

b) Fourth character from the left shall be an asterisk (*), a plus sign (+) or a hyphen (-). Do not use other punctuation symbols in a wire designator.

c) Remaining characters shall be alphanumeric and make wire designator unique.

d) Numbering shall reflect actual designations used in the Work and shall be documented in record documents.

c. Cabinet, Console, Panel, and Enclosure Wiring, Internal:

1) New Cabinets, Consoles, Panels, and Enclosures:

a) Wire and cable inside cabinets, consoles, panels, and enclosures shall have designators as specified in Section 40 61 13, Process Control SYstem General Provisions.

6. Modified Cabinets, Consoles, Panels, and Enclosures:

a. New or rerouted wire or cable in existing cabinets, consoles, panels, and enclosures shall be labeled as shown on the Drawings or be assigned a ten-character designator equivalent to field wire designator.

H. Terminal Strip Labeling:

1. Label panel side of terminal to match panel wire number.
2. Label field side of terminal to match field wire number. Terminal number shall not include the Contract number.

I. Generator System Warning Signs:

1. Provide warning signs for generator systems as required by NEC.
2. Install generator location warning sign on or immediately adjacent to service equipment, or to “normal” source disconnecting means when generator is located out of sight of service equipment or disconnecting means.
3. Install generator grounding warning sign on enclosure or immediately adjacent to point where generator neutral is connected to grounding electrode system if connection is made remote from generator.

J. Detectable Underground Warning Tape:

1. Warning Tape shall be placed in trenches with backfill about 12 inches below finished grade on all medium voltage underground conduit runs and others as indicated on the Contract Drawings.

+ + END OF SECTION + +

SECTION 16100

ELECTRICAL DEMOLITION

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. Furnish all labor, equipment, materials, and supplies necessary for and reasonably incidental to demolition of work hereinafter specified, indicated on drawings, required or intended for completion of the work.

B. Major items included under demolition work include, but are not limited to:
   1. Electrical equipment and connections associated with existing Flocculation/Sedimentation Basins.
   2. Interior electrical, lighting, etc. in the third floor area of the existing Filter Building, as called out on contract drawings.
   3. Electrical equipment and connections located within the existing Tunnel. Majority of equipment will be relocated.

C. Repair those areas damaged under demolition work once new services and systems have been installed.

1.2 SUBMITTALS

A. No submittals are anticipated under this Section.

1.3 JOB CONDITIONS

A. Provide adequate protection to persons and property. Execute work in such a manner as to avoid interference with required operations and use of or passage to and from adjoining buildings and facilities.

B. Demolition work of equipment necessary for the operation of the power and communication systems to be coordinated with the installation of new equipment. The demolition and installation work is to be done as quickly as possible to minimize any burdens on the Owner.

1.4 CONDITION OF EXISTING FACILITIES

A. Contractor shall verify the areas, conditions and features necessary to tie new work into existing construction. This verification shall be done prior to submittal of shop drawings, fabrication or erection, construction or installation. The Contractor shall be responsible for the accurate tie-in of the new work to existing facilities.

PART 2 – PRODUCTS

Not Applicable

PART 3 – EXECUTION

3.1 SCHEDULES

A. Schedule all demolition work as to cause minimal interference with existing facility operations. Refer to Specification Divisions 0 and Division 1 for additional requirements.

B. Obtain prior approval of the Owner at least seven days in advance before starting demolition of any equipment. Under no circumstances will demolition work be approved until new equipment is ready for installation.

3.2 PREPARATION

A. Disconnect or arrange for disconnection of utility service connections to equipment and areas to be demolished before starting demolition.

B. Preserve in operating condition all active utilities transversing the project site. Protect all equipment that remains (electrical and mechanical) during demolition, and repair all damage caused by this work to satisfaction of Engineer.

3.3 APPLICATION

A. Maintain the continuity of the existing branch circuits serving all existing light fixtures, receptacles, or equipment that are to remain, whether indicated or not on the drawings.

B. All existing walls, ceilings, floor slabs, etc., being cut or damaged under this Contract shall be patched back to match existing by General Contractor.

C. At the discretion of the Owner, all existing switchgear, lighting fixtures, receptacles, control equipment and switches being removed shall be disposed of by the Contractor. Refer to 16050 for more details.

D. Remove exposed ground conductor back to source or point of contact with slab. Cut conductor off below slab and abandon with hole being patched back to match existing surface (floor, wall or ceiling). If reusable, simply disconnect ground conductor.

E. Conduits, wire and wood products that are not salvageable shall be disposed of legally.

F. Primary work shall be completed with all facilities kept in service or with short periods of scheduled momentary outages.

G. Holes in slabs or into classified areas to be patched to provide a gas, vapor and watertight barrier.

3.4 STORAGE AND HANDLING

A. The Owner reserves the right to save materials that are a part of the demolition work, and the Contractor shall turn over and store any such materials at the Owner's direction.

B. All materials not turned over to Owner shall become property of Contractor and removed promptly from project site at no additional cost to the Owner. Any permits or fees for disposal shall be the responsibility of the Contractor.

3.5 CLEANUP

A. Burn no materials or debris on premises.

B. Remove from site rubbish and debris found thereon and, except as otherwise specified, materials and debris resulting from work of demolition. Leave site in safe and clean condition.

+ + END OF SECTION + +

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SECTION 16120

CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. All wire and cable shall conform to the latest requirements of the NEC and shall meet all ASTM/UL specifications. Wire and cable shall be new; shall have size, grade of insulation, voltage rating and manufacturer's name permanently marked on the outer covering at regular intervals. Complete descriptive literature shall be submitted to the Engineer for review and acceptance prior to installation.

B. Building wire #12 - #1 shall be applied based on a 60 degree Celsius temperature rise. Building wire larger than #1 may be applied at its 75 degree Celsius temperature rise.

1.2 DELIVERY, STORAGE AND HANDLING

A. Wire and cable shall be suitably protected from weather and damage during storage and handling and shall be in first class condition when installed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Building Wire (types "THWN" and "THW"-cu.) – "Collyer," "Rome," "American," "Carol," or equal.

B. Flexible Cords and Cables (Types "SO" (600V) "SJO" - 300V) "Collyer," "American," "Carol,"or equal.

C. Instrumentation Cables (Shielded) 600V mx. – "Eaton-Dekoron," "Manhatton," "American," "Belden," "Okonite," or equal.

2.2 MATERIALS

A. General
   1. In general, all conductors shall be 98 percent conductive, annealed copper unless otherwise noted on the Contract Drawings.

   2. Conductors shall be type THWN insulation. Conductor size shall be AWG (American Wire Gauge) Standard. Minimum conductor size shall be AWG

number 12 except branch circuits in excess of 75 feet from panel to first outlet not smaller than no. 10 AWG. Minimum voltage rating shall be 600 volts. Conductors for small power may be solid (i.e. lighting, receptacles), but conductors for control work shall be stranded.

3. Conductors with high temperature rated insulations and special construction shall be used where required in connecting to light fixtures or appliances that have special requirements.
4. Communication Cables (including telephone cables shall be as specified in this Section 16710, Communications Systems.

B. Instrument Cables
   1. Refer to Part 3 of this specification section.

C. VFD Cable
   1. The cable shall be 600V/1000V rated, with stranded tinned copper conductors, shielded, suitable for use with Variable Frequency Drives.
   2. The insulation shall be rated for 90 degrees Celsius Wet/Dry operating temperature.
   3. Accessories (terminations) shall have ratings that are at least equal to those of cable.
   4. All cables shall be round.
   5. Cable shall be suitable for use in wet/dry locations, indoors and outdoors, in cable trays, in conduit, trenches, and in underground ducts and direct burial.
   6. The conductor shall be annealed stranded tinned copper per ASTM B3, B8, and B33.
   7. The insulation thickness shall have a minimum average wall thickness of 30 mils. The insulation material must be XLPE with an XHHW-2 listing per UL 44. Each insulated conductor shall be identified in accordance with ICEA Method 4 color coding.
   8. The insulated conductors are to be cabled together with a minimum of one ground wire. The ground wire(s) are to have a minimum circular mil area equivalent to one circuit conductor. Fillers shall be included as necessary to make the cable round.
   9. The cabled assembly shall be shielded using one of two methods:
      a. Applying helically two 2-mil copper tapes. The shield shall provide 100% coverage over the assembly.
      b. Applying an 80% minimum coverage tinned copper braid shield used in conjunction with an Aluminum Foil shield tape.
   10. All cables shall have a continuous overall outer sheath of Polyvinyl Chloride (PVC), suitable for 90 degree Celsius use.
   11. The jacket shall be resistant to abrasion, rated for direct burial, sunlight resistant, and flame resistant in accordance with UL 1277.
   12. The following permanent legend shall be clearly embossed or printed at approximately 2 foot intervals on the outer jacket for the entire length of the cable:
      a. Manufacturer’s name and/or Trade Mark.
      b. Number of conductors and size (--AWG).

c. Type of insulation (XLPE) or NEC Listed Conductor Type (XHHW-2).
d. Voltage rating.
e. TC-ER rating.
f. 1000V Flexible Motor Supply Cable rating.
g. Sequential footing marking at 2 foot intervals.

13. Only one continuous (without splices) length of cable shall be shipped on a reel. Both ends shall be waterproof sealed, secured, protected from damage, and both ends shall be available for testing.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. General

1. Conductors shall be continuous from outlet to outlet and no splices shall be made except accessible in junction or outlet boxes. Wire connectors of insulating material or solderless pressure connectors, properly taped, shall be used for all splices in wiring, wherever possible.
2. Conductors shall be color coded in accordance with the following schedule:

	480/277V 3 Phase	**208/120V 3 Phase**	**120/240, Single Phase**
Phase A	Brown	Black	Black
Phase B	Orange	Red	Red
Phase C	Yellow	Blue	
Neutral (Grounded)	White or Light Gray	White or Light Gray	White or Light Gray
3-Way Tracers			Blue
Grounding	Green	Green	Green
Remote Energized Conductors (Control)			Orange
Control	Per NFPA 79	Per NFPA 79	

3. Conductors shall be pulled into raceways in strict accordance with manufacturer's recommendations.
4. Ample slack conductors shall be allowed at each terminal point, and pull or junction box, to permit installation with ease and without crowding.
5. All conductors terminating at terminal blocks shall be identified per Specification Section 16075, Electrical Identification, with numbers and/or letters identical to circuit or control identification.
6. No conductors shall be drawn into conduits until all work which may cause wire or cable damage is completed. Wire pulling shall be accomplished utilizing machinery and accessories intended for the purpose.

7. All connections and splices shall be made in accordance with conductor manufacturer's recommendations, and as written herein.
8. If the size and number of conductors in a conduit on the Drawings is not shown, then it shall be assumed to be 3 #12, 3/4" C.
9. In general, feeder sizes shown are based on no more than three current carrying conductors in a conduit. Multiple small branch circuit feeders may be combined in a common conduit, provided conductors are derated in accordance with NEC article 310.15.
10. Unless otherwise specifically indicated, neutrals may not be shared.

B. Low Voltage Feeders
1. All feeders are of the secondary type, below 600-volts, unless otherwise noted. Secondary feeder voltage shall be 480-volt, 240-volt, or 208-volt as noted in the Contract Drawings. Three-phase, 4-wire for power and 208/12-volt, 3-phase, 4-wire for general lighting, unless otherwise noted. The Contractor shall furnish and install all feeders from the distribution center(s) to each of the other structures/subpanels as shown on the Contract Drawings.
2. Wire shall be factory color coded for each phase and neutral, with green used for the grounding conductor. As far as practical, all feeders shall be continuous from origin to panel termination without running splices in intermediate pull boxes.
3. A grounding conductor shall be installed, sized per code, within every conduit containing voltages above 24VAC. Although the metallic conduit system shall be bonded, the metallic conduit systems shall not be the sole source of bonding.

C. Single Shielded Pair Instrument Cable
1. Tinned copper, XLPE insulated stranded conductors, No. 16 AWG minimum, twisted pair with overall shield, stranded tinned No. 18 AWG copper drain wire and overall PVC jacket. Rated for 600 volts minimum and conforming to UL 1581.
2. Manufacturers: Provide products of one of the following:
   a. Belden Company.
   b. Okonite Company.
   c. Dekoron Wire and Cable Company.
   d. Or equal.

D. Multi-paired Shielded Instrument Cable:
1. Tinned copper, XLPE insulated stranded conductors, No. 16 AWG minimum, twisted pairs with shield over each pair, stranded tinned No. 18 AWG copper drain wire, and overall PVC outer jacket. Rated for 600 volts minimum and conforming to UL 1581 or UL 13.
2. Manufacturers: Provide products of one of the following:
   a. Belden Company.
   b. Okonite Company.

c. Dekoron Wire and Cable Company.
d. Or equal.

E. Submersible Pump Power Cable:

1. Power cables for submersible pumps shall be of the extra hard usage type suitable for submerged duty and able to withstand common corrosive agents found in water and wastewater. They shall be provided with high grade non-magnetic stainless steel relief cable grips installed at the pump end and high grade non-magnetic stainless steel support cable grips anchored to the wet well structure where they enter the wet well. The strain relief and support cable grips shall be as manufactured by Kellems, Slater/Flexcor, or equal. Non-metallic corrosion resistant grips may be used in lieu of stainless steel if available for the cable size.

+ + END OF SECTION + +

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SECTION 16125

COMMUNICATIONS CABLE AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, equipment and incidentals required to provide communications cable as shown on the Drawings, specified or required.

B. Cabling required for this project include:
   1. Category 6 unshielded twisted pair (UTP) for 100 Base-TX Ethernet Local Area Network.

C. Related Sections:
   1. Section 16126, Fiber Optic Cable and Appurtenances.

1.2 REFERENCES

A. Reference Standards: Comply with applicable provisions and recommendations of the following except where otherwise shown or specified.
   1. ANSI/TIA/EIA-568-A, Commercial Building Telecommunications Cabling Standard.
      a. The requirements and restrictions of Technical Service Bulletins (TSBs) will apply.
   2. IEEE 802.1H, Local and Metropolitan Area Networks IEEE Recommended Practice for Media Access Control (MAC) Bridging on Ethernet.
   3. IEEE 802.3, Local Area Networks Carrier Sense Multiple Access with Collision Detection (CSMA/CD)--(ETHERNET).
   4. IEEE 802.10f, Local and Metropolitan Area Networks--IEEE Standards: Recommended Practice for Secure Data Exchange (SDE) on Ethernet.

1.3 SUBMITTALS

A. Product Data:
   1. Manufacturer data sheets for the cable, connectors and termination devices.
   2. Manufacturer data sheets and catalog information for test equipment.
   3. Calibration Certificates for Test Equipment.
   4. Installation tools, requirements and procedures.

B. Shop Drawings:
   1. Drawing of proposed layout showing outlet wall locations and configuration, cable routing, equipment locations and patch panel terminations.
      a. Include mounting and installation details for equipment.

C. Project Record Documents: Submit record drawings with the following information:
   1. Actual outlet wall locations, configuration and labeling.
   2. Actual cable routing and equipment locations.
   3. Actual patch panel terminations and labeling.

D. Quality Assurance/Control Submittals:
   1. Field Test Reports: Contractor shall submit certified field reports. Refer to Paragraph 3.1 for test requirements.

1.4 QUALITY ASSURANCE:

A. Manufacturer Qualifications: Manufacturer shall be experienced in manufacturing materials and equipment similar to that which is specified herein for at least five years, with a record of successful in-service performance. When requested by the Engineer, a list of installations in satisfactory operation shall be provided.

PART 2 - PRODUCTS

2.1 DATA CABLING

A. Horizontal Unshielded Twisted Pair (UTP) Cable:
   1. General: Horizontal cabling is the cabling between and including the telecommunications outlet/connector and the patch panel or termination block.
   2. The cable shall consist of 24 AWG thermoplastic insulated solid conductors formed into four individually twisted pairs and enclosed by a thermoplastic jacket.
   3. The cable shall meet all requirements of ANSI/TIA/EIA-568-A, part 10.2.
   4. The cable shall be riser rated where run in conduit. All other installations shall be plenum rated.
   5. The cable shall be rated for Category 6 use.
   6. Manufacturer: Provide one of the following:
      a. Bertek.
      b. Belden.
      c. Mohawk
      d. Or equal.

B. Patch Cords:
   1. General: Patch cords are used to connect patch panel to hub or wall jack to equipment.
   2. The cable shall consist of 24 AWG thermoplastic insulated stranded conductors formed into four individually twisted pairs and enclosed by a thermoplastic jacket.
   3. The cable shall be riser rated.

4. The cable shall be rated for Category 6 use.
5. The cable shall incorporate integral strain relief into the connector at each end. Connectors shall be RJ45 plugs.
6. Provide the following patch cords:
    a. One 10 foot cable per wall jack installed.
    b. One 3-foot cable per every two wall jack installed.
    c. One 6 foot cable per every two wall jack installed.
7. Manufacturer: Provide one of the following:
    a. Bertek.
    b. Belden.
    c. Mohawk
    d. Or equal.

C. Connecting Hardware for Unshielded Twisted Pair (UTP) Cable:
1. Hardware used to terminate UTP cable shall meet all requirements of ANSI/TIA/EIA-568-A, part 10.4.
2. The connecting hardware shall be compatible with the wiring specified above.
3. Connecting hardware shall be rated for Category 6 use.
4. Connecting hardware shall utilize 110 type terminal blocks to coordinate with patch panels and termination blocks specified below.
5. Telecommunications outlets/connectors:
    a. Outlets and connectors shall utilize RJ45 (8 pin modular) plug/receptacle configuration.
    b. Outlets and connectors shall utilize T568B pin/pair assignments.
    c. Outlets and connectors shall be coordinated with wire type (solid or stranded conductor).
    d. Outlets shall be flush mount or surface mount as indicated on the Drawings.
    e. Manufacturers: Provide one of the following:
        1) Hubbell.
        2) Or equal.
6. Patch Panels:
    a. Patch panels shall utilize RJ45 (8 pin modular) plug/receptacle configuration.
    b. Patch panels shall utilize T568B pin/pair assignments for the receptacles.
    c. Patch panel terminations shall be coordinated with wire type (solid or stranded conductor).
    d. Patch panels shall be wall mount or rack mount as indicated on the Drawings.
    e. Patch panel shall be listed as Category 6.
    f. Provide a minimum number of ports equal to number of wall jacks installed in the building/area served plus 50 percent spare.
    g. Manufacturers: Provide one of the following:

1) Black Box.
2) Or equal.

D. Equipment Rack:
1. General:
a. Provide a nameplate for the enclosures in compliance with Section 16075, Electrical Identification.
b. Rails shall be pre-tapped and drilled for their full height per EIA standards.
2. Enclosed Floor Mount Mini-Rack:
a. 36 inches high, 19 inches wide relay rack mounted within an enclosure with a nominal depth of 20 inches.
1) Side rails for full height for equipment attachment.
2) Side panels shall be solid, gasketed construction with quarter-turn fasteners for easy removal.
3) Window frame front door with key latch and two keys (keys shall operate both front and rear doors).
4) Solid rear door with key latch.
5) Raised top cover with 4mm perimeter ventilation openings.
6) Base plate with ventilation slots.
3. Enclosed Wall Mount Mini-Rack:
a. Enclosure shall be double-hinged to allow access to the back of mounted equipment.
b. Side rails for full height for equipment attachment.
c. Top, bottom and side panels shall be solid.
d. Window frame front door with key latch and two keys (keys shall operate both front and rear doors).
e. Back hinge shall be lockable in the closed position to limit rear access.
4. Accessories:
a. 6 outlet rack mount power strip with 15 foot cord and plug.
b. One fixed vented equipment shelf.
c. One sliding keyboard shelf.
5. Product and Manufacturer: Provide one of the following:
a. Hoffman.
b. Hergo
c. APW Zero Stantron.
d. Or equal.

PART 3 - EXECUTION

3.1 DATA CABLING

A. Installation:

1. Where data cables are run through walls or above drop ceiling they shall be grouped and neatly bundled with wire ties. Cable bundles shall be securely supported.
2. Where cables run between floors or through fire rated walls the cables shall be protected from damage and shall be firestopped.
3. Cables run exposed or in non-office areas shall be in conduit.
4. Data system cables and conduit shall be separate from any other cables and conduit system.
5. All conduits containing data cables shall be marked in compliance with Section 16075, Electrical Identification.
6. All bundled data cables shall be marked at maximum 50-foot intervals along the cable run. The word "DATA" shall be provided on a tag, which shall be affixed to the cable bundle. Markings shall comply with Section 16075, Electrical Identification.
7. Data cables shall terminate at offices and other rooms as shown on the drawings, in a surface or flush-mounted jacks. Flush mounted jacks shall be used where practicable. Duplex jacks and simplex jacks shall be labeled "DATA" and be in compliance with Section 16075, Electrical Identification.
8. Network data cables shall <u>not</u> be spliced.
9. Pulling:
    a. Insulating gel pulling compounds containing no mineral oil shall be used.
    b. Pulling tension shall be within the limits recommended by the cable manufacturer.
    c. Where mechanical means are used, pulling tension shall be monitored by use of a dynamometer. Cable manufacturer's pulling tension limits shall not be exceeded.
    d. Cable sections subjected to mechanical means shall be cut off and discarded.
    e. Cable shall be carefully handled and protected prior to and during installation to ensure that no damage will result.
10. Slack shall be provided at terminations.
11. Integrity of color coding shall be maintained at connections.
12. Where equipment provided in this Contract is installed into or connected to existing equipment, the work shall be done in the presence of the Owner. Any work that may disrupt network operations shall be scheduled as an outage.
13. When installation of the new equipment requires changes to the configuration of the existing equipment, the existing equipment shall be reconfigured by the Owner with direction and technical support provided by the Contractor.

B. Field Quality Control:
    1. Each circuit shall be tested after permanent cables are in place to demonstrate that the circuit and connected equipment perform satisfactorily and that they are free from noise, improper grounds and short circuits.

2. Testing shall be witnessed by the Engineer. The Engineer shall be notified at least 24 hours in advance of testing.
3. A written record of circuits being tested shall be maintained. The written record shall contain the circuit number or descriptive function, and the results of each step in the test procedures including repeated tests. Test Reports shall be signed by the tester, initialed by the Engineer and submitted within ten days.
4. All telecommunications circuits shall be certified as being Category 6.
5. Any cable which fails the Category 6 certification test shall be reworked and/or replaced until it passes the certification. Retesting and replacement shall be at the Contractor's expense.

C. Test Equipment:
   1. All test equipment shall be provided by the Contractor.
   2. The test equipment used by the contractor shall comply with the following:
      a. Equipment shall consist of a "master" and a "remote" unit.
      b. Test of all aspects of the cable shall be automatic and initiated with a single command. The unit shall test over the entire frequency range. Unit shall be capable of accepting cable identification tag for reporting purposes. Unit shall return a "pass/fail" status for the cable and, if "fail", the reason for the failure.
      c. Unit shall be able to store all test results internally and print the results at a later date.
      d. Unit shall be specifically designed and manufactured to certify cabling systems as being Category 6 compliant.

+ + END OF SECTION + +

SECTION 16127

TELEPHONE CABLE

PART 1 -- GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install telephone cable.

1.2 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for cable proposed for use.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. Multiconductor Telephone Cables:
   1. Trunk Lines: Tinned copper, stranded conductors, No. 20 AWG, 24 twisted, individually shielded pairs with PVC insulation and 60 mil PVC jacket overall. Rated 300 volts minimum.
   2. Extension Lines: Tinned copper, stranded conductors, No. 20 AWG, 12 conductor, PVC insulation and chrome PVC jacket. Rated 300 volts minimum.
   3. Phones: Solid copper, No. 22 AWG, 4 conductor, polyethylene insulated and PVC jacket, rated 300 volts minimum.
   4. Product and Manufacturer: Provide telephone cables manufactured by the following:
      a. Series No. CW-62910 by Cablec Continental Company for trunk lines.
      b. No. 9457, (Extensions), No. 9794 (Phones) by Belden Company.
      c. Or equal.

B. Cable Terminals:
   1. Fork type copper compression terminals with nylon insulation for termination of cable at all terminal blocks.
   2. Product and Manufacturer: Provide one of the following:
      a. T&B Sta-Kon.
      b. Burndy Insulug.
      c. Or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Install all cable complete with proper terminations at both ends.

B. Install in conduit separate from power cables unless otherwise noted.

C. Identify all conductors in accordance with Section 16075, Electrical Identification.

D. Install and terminate vendor furnished cable in accordance with vendor equipment requirements and cable manufacturer's specific recommendations.

E. Install in conformance with the National Electrical Code.

3.2 TESTING

A. Test cable with an ohmmeter for continuity along the full length of the cable and for continuity to ground.

B. Any cable which fails any test or when used under full load conditions shall be replaced with a new cable for the full length.

+ + END OF SECTION + +

SECTION 16130

RACEWAYS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section of the Technical Specifications includes all raceways for accommodation of electrical conductors, communications conductors, sleeves for underground electrical installations, conduit stubs for future installations, fittings and accessories.

B. All raceways shall be marked with the manufacturer's name or trademark as well as type of raceway and size. This marking shall appear at least once every 10 feet and shall be of sufficient durability to withstand the environment involved. All raceways shall be furnished and installed as outlined under Part 3 of this Specification.

C. All raceways and fittings shall be painted to match existing or surrounding surfaces except in mechanical spaces.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Tubular Raceways
   1. Steel, Galvanized, Rigid, Heavy-Wall, Threaded – "Wheatland Tube Co.," "Triangle," "Allied Tube & Conduit Corp.," or equal.
   2. Steel, Galvanized, Thin-Wall, Electric-Metallic-Tubing (EMT) – "VAW," "Triangle," "Allied Tube & Conduit Corp,." or equal.
   3. Aluminum, Rigid, Heavy-Wall, Threaded – "VAW," "Alcoa," "Reynolds," or equal.
   4. Plastic (PVC); Type A (Thin Wall); Type 40 (or Schedule 40); Type 80 (or Schedule 80) (Heavy -Wall) – "Robin-Tech," "Carlon," or equal.
   5. Flexible Metal Conduit – "AFC," "Alflex," or equal.
   6. Liquidtight Flexible Metal Conduit – "Carol Cable Co., Inc.," "Superflex," "OZ Gedney," or equal.
   7. Factory Coated Aluminum Conduit - Alumax "ALX-1", or equal.
   8. Fiberglass Conduit- FRE Composites, United Fiberglass, or equal.

B. Surface Metal raceways
   1. "Iso-duct," "Wiremold," "Walker," or equal.

C. Wireways

1. "Square-D," "Hoffman," or equal.

D. Raceway Fittings
   1. Conduit fittings – "Crouse-Hinds," "Appleton," "OZ Gedney," or equal.
   2. Non-metallic conduit fittings – "Robin-Tech," "Carlon," "Scepter," or equal.
   3. Surface metal raceway fittings and fasteners shall be provided by the manufacturer of the raceway.
   4. Flexible conduit fittings – "Raco," "T & B," "OZ Gedney," or equal.

2.2 MATERIALS

A. Aluminum Conduit
   1. Aluminum conduit shall be extruded from alloy 6063 and shall be the rigid type, non-toxic, corrosion resistant, and non-staining. It shall be manufactured per UL standards as well as listed/labeled by same.
   2. Fittings, boxes, and accessories used in conjunction with aluminum conduit shall be die cast, copper free type. They shall be resistant to both chemical and galvanic corrosion. All covers shall have neoprene gaskets.
   3. Aluminum conduit proposed for concrete slab or underground applications shall be UL listed for the purpose and factory pre-coated.

B. Rigid Steel Conduit
   1. Rigid steel conduit and fittings shall be of mild steel piping, galvanized inside and out, and shall conform to UL standards. The conduit and fittings hall be listed and labeled by UL as well. The galvanized coating of zinc shall be of uniform thickness applied by the hot-dipped process, and shall be applied also to the threads. It shall be further dipped in a chromic acid bath so as to chemically form a corrosion resistant protective coating of zinc chromate which has a characteristic yellow-green color. Each piece of conduit shall be straight, free from blisters and other defects, cut square, and taper reamed. It shall be delivered with plastic protectors on the threads.

C. Polyvinylchloride (PVC) Conduit
   1. PVC conduit and fittings shall be Schedule 40, 80 heavy wall, or thinwall, as indicated in these Specifications manufactured to conform to UL standards. It shall be listed and labeled by UL. It shall have at least the same temperature rating as the conductor insulation. Expansion joints shall be used as recommended by the manufacturer in published literature. PVC systems shall be 90 degrees Celsius minimum UL rated, have a tensile strength of 7,000 psi @ 73.4 degrees Fahrenheit, flexural strength of 11,000 psi and compressive strength of 8,000 psi.

D. Electrical Metallic Tubing (EMT)
   1. EMT shall be high grade steel with an exterior galvanized coating of zinc applied uniformly by the electro-galvanized process. The interior surface shall be uniformly coated with aluminum lacquer or enamel. After

galvanizing, it shall be dipped in a chromic acid bath to chemically form a protective coating of zinc chromate. The conduit shall conform to UL standards and be listed as well as labeled by UL.

E. Surface Metal Raceway
   1. Surface metal raceway shall be 2 piece type, base mounted with snap-on cover. Raceway installation shall be in accordance with manufacturers instruction, using adapters and fittings specifically designed and manufactured for the raceway used.

F. Flexible Conduit
   1. Flexible metallic conduit shall be constructed from flexibly or spirally wound elecro-galvanized steel. Connections shall be by means of galvanized malleable iron squeeze type fittings, or tomic twist-in type in sizes not exceeding 3/4 inch. Liquidtight conduit shall be light gray in color and have sealtight fittings, type UA.

G. Conduit Fittings
   1. Rigid Steel Conduit Fittings
      a. Standard threaded couplings, locknuts, bushings, and elbows made only of steel or malleable iron are acceptable. Integral retractable type IMC couplings are acceptable also.
      b. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
      c. Bushings: Metallic insulating type, consisting of an insulating insert molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
      d. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted or use to complete a conduit run where conduit is installed in concrete. Use set screws of case hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
      e. Sealing fittings: Threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water vapor. In concealed work, installed fittings in flush steel boxes with blank coverplates having the same finishes as that of other electrical plates in the room.
      f. Fittings for PVC coated rigid conduit shall be manufactured by the maker of the conduit.
   2. Rigid Aluminum Conduit Fittings
      a. Standard threaded couplings, locknuts, bushings, and elbows: Malleable iron, steel or aluminum alloy materials. Zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are prohibited.
      b. Locknuts and bushings: As specified for rigid steel and IMC conduit.
      c. Set screw fittings: Not permitted for use with aluminum conduit.
   3. Electrical Metallic Tubing Fittings
      a. Only material of steel or malleable iron is acceptable.

b. Couplings and connectors: Concrete tight and rain tight, with connectors having insulated throats. Use gland and ring compression type couplings and connectors for conduit sizes 2-inches and smaller. Use set screw type couplings with four set screws each for conduit sizes over 2-inches. Use set screws of case hardened steel with hex head and cup point to firmly seat in wall of conduit for positive grounding.
c. Indent type connectors or couplings are prohibited.
d. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.

4. Expansion and Deflection Couplings
   a. Accommodate 1.9 cm (0.75 inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
   b. Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents in accordance with UL, and the NEC code tables for ground conductors.
   c. Watertight, seismically qualified, corrosion-resistant, threaded for and compatible with rigid or intermediate metal conduit.
   d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material and stainless steel jacket clamps.

H. Handholes and Box for Exterior Underground Wiring
   1. General Requirements for Handholes and Boxes:
      a. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
      b. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
      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) Quazite Company.
         2) Carson Industries LLC.
         3) CDR Systems Corporation; Hubbell Power Systems.
         4) Oldcastle Precast, Inc.; Christy Concrete Products.
         5) Synertech Moulded Products; a division of Oldcastle Precast, Inc.
      b. Standard: Comply with SCTE 77.
      c. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
      d. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
      e. Cover Finish: Nonskid finish shall have a minimum coefficient of

friction of 0.50.

f. Cover Legend: Molded lettering, Text as indicated.
g. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
h. Handholes: Sizes as indicated.

I. Source Quality Control for Underground Enclosures
1. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
a. Tests of materials shall be performed by an independent testing agency.
b. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
c. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

A. Exterior underground metallic conduits shall be degreased, pretreated, and coated with 2 coats of Carboline 888 epoxy, or equal. Other finishes may be acceptable upon the Engineer's review.

3.2 INSTALLATION

A. Conduit
1. All conduit shall be installed in a first class workmanship manner. It shall be installed in horizontal and vertical runs in such a manner as to ensure against trouble from the collection of trapped condensation and shall be arranged so as to be devoid of traps wherever possible. Special care shall be used in assuring that exposed conduit runs are parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. No open wiring is allowed.
2. Fittings or symmetrical bends shall be required wherever right angle turns are made in exposed work. Bends and offsets shall be avoided wherever possible, but where necessary, they shall be made with an approved conduit bending machine. All conduit joints shall be cut square, reamed smooth and drawn up tight, using couplings intended for the purpose.
3. Conduits shall be securely fastened to all sheet metal outlets, junction and pull boxes with double galvanized locknuts and insulating-grounding bushings as required by the NEC. Conduit crossings in insulating roof fill will require both conduits to be secured to the roof deck, and these crossings

can only be made where the insulating fill is a minimum of 3 inches deep. Runs of exposed conduit shall be supported in accordance with the NEC using cast aluminum or malleable iron one hole pipe straps with spacers to provide an air space behind the conduit. Stainless steel minerallac, one piece conduit clamps shall be acceptable where located such that building occupants are not in danger of inadvertent contact, since this type fitting has several sharp edges. In general terms, they may be considered in areas such as on or above ceilings, or high on walls. All conduit in walls and slabs shall be securely braced, capped (wooden plugs are prohibited), and fastened to the forms to prevent dislodgement during vibration and pouring of concrete.

4. During construction, all conduit work shall be protected to prevent lodgement of dirt, plaster or trash in conduits, fittings or boxes. Conduits which have been plugged shall be entirely freed of accumulations or be replaced. All conduits in floors or below grade shall be swabbed free of debris and moisture before wires are pulled. Crushed or deformed conduit shall not be permitted.
5. All open conduit work through new walls or slabs shall be run through sleeves that shall be made watertight. These sleeves shall be PVC of suitable diameter to permit the passage of the conduit used.
6. Where GRS conduit penetrates a floor slab the conduit shall be painted with 2 coats of Koppers Bitumastic 300-M or equal to a point 6 inches above the penetration.
7. The final section of conduit connecting each motor or piece of utilization equipment subject to vibration shall be of the flexible type. Type "UA" shall be used in all process areas and in outdoor or wet locations. Flexible conduit to space heaters shall be long enough to allow swivel action.
8. All underground conduits entering a building shall be sealed against water/condensate entering around the conductors. Sealant may be silicone rubber based caulk.
9. In certain situations, conduit expansion joints shall be required to ensure against conduit and/or cable damage due to settling or thermal expansion and contraction. These expansion joints shall be required where required by the manufacturer or the Contract Drawings and shall be installed per manufacturers instructions.
10. Control panels, panelboards, etc., mounted in a building with a basement or pipe gallery below, shall have the conduit opening left in the slab sealed to prevent moisture, dust, etc., from entering the panel. The type of seal to be used shall be silicone elastomer foam, as manufactured by Dow-Corning, Chase-foam as manufactured by Chase Technology Corporation, T & B, or equal.
11. All conduit to be added to an existing structure shall be exposed in unfinished and process areas. Where new devices are shown in existing walls in finished spaces, every attempt shall be made to conceal the conduit, by fishing flexible conduit through walls from ceiling cavities.
12. All conduit work in the finished space of each new structure shall be concealed except for conduits to lighting fixtures in buildings with precast

roof slabs, open joist ceilings, or excepted as noted on the Contract Drawings. All conduit work below ground floor level in each structure shall be exposed. Conduits entering from underground into buildings shall be watertight through the wall, both inside and outside.

13. PVC conduit installed underground for low voltage application shall be schedule 40 encased in 4" of concrete. Where PVC conduit is installed, transition shall be made to PVC coated GRS conduit where routing through concrete.
14. Aluminum conduit shall not be used underground, in chlorine storage/feed areas, or placed in concete slabs.
15. Conduit stubs, for future use, extended through outside walls shall be capped with threaded pipe caps and coated to prevent corrosion. Stubs shall extend 5 feet beyond the walls from which they are stubbed unless otherwise indicated on the Contract Drawings.
16. All metal raceway systems shall be grounding conductive, solidly bonded throughout and grounded in accordance with NEC requirements and/or as noted on the Contract Drawings. In addition, all raceway systems shall be provided with separate grounding conductors.
17. Minimum conduit size shall be 3/4 inch. The following table shows the minimum burial depth required for all exterior conduit or cable:

Rigid Metal Conduit	24"
Encased Schedule 40 PVC	24"

18. Wire pulling shall be facilitated by the use of a UL approved pulling compound in pulls over 30 feet in length or where there are 2 or more 90 degree bends. Only polypropylene, nylon, or manila pulling ropes will be permitted. Standard industry recognized wire pulling equipment shall be used.
19. All conduits entering and leaving instrument enclosures shall be sealed around the wires with silicone caulk.
20. Areas of use for each type of conduit:

Buildings – Interior	**Schedule 40 PVC**	**Schedule 80 PVC**	**EMT**	**GRS**	**Fiberglass**	**Aluminum**
Process Areas (Exposed)				X	X	X
Process Areas (Concealed)	X	X		X	X	X
Non Process Areas (Exposed)				X		X
Non Process Areas (Concealed)	X	X	X	X	X	X
Chemical Feed Rooms (Exposed)		X			X	X
Chemical Feed Rooms	X	X			X	

Buildings – Interior	Schedule 40 PVC	Schedule 80 PVC	EMT	GRS	Fiberglass	Aluminum
(Concealed)						
Carbon Feed Room						X

Exterior Underground	Schedule 40 PVC	Schedule 80 PVC	EMT	GRS	Fiberglass	Aluminum
Low Voltage	X	X		X	X	
Low Voltage Service Entrance (Concrete Encased)	X	X		X		

Exterior Exposed	Schedule 40 PVC	Schedule 80 PVC	EMT	GRS	Fiberglass	Aluminum
Low Voltage				X		X

21. Surface metal raceways (SMR) shall be employed in all existing structures for wiring which must be exposed in the finished space.
22. Underground raceways (conduit) shall be provided with steel sleeves where they pass over or under obstructions, such as: sidewalks; roadways; piping; etc.
23. Surface metal raceway use shall be held to a minimum, but where needed, it shall be at least the equivalent size of wiremold 750 series.
24. All conduit shall have an insulated ground wire pulled to all equipment and receptacles.
25. EMT conduit fittings shall be compression type.
26. All raceway runs are shown diagrammatically to outline the general routing of the raceway. The installation shall be made to avoid interference with pipes, ducts, structural members or other equipment. Should structural or other interference prevent the installation of the raceways, or setting of boxes, cabinets, or the electrical equipment, as indicated in the Drawings, deviations must be approved by the Owner, and after approval, shall be made without additional charges and shown on the Record Drawings.
27. Fire Stop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases, with rock wool fiber or silicone foam sealant only. Completely fill and seal clearances between raceways and openings with the fire stop material. See Section 15305 for complete fire stop requirements.
28. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.
29. No conduit shall be run exposed across roofs without first obtaining permission from the Engineer.
30. Conduit may be run inside concrete slabs as long as the slab is at least 6-inches thick and conduit will have at least 1 2-inches of cover on both sides.
31. Flexible conduit used in mechanical rooms shall be liquid tight.

32. Runs of flexible conduit above accessible ceilings shall be limited to 10 ft. Runs of exposed flexible conduit shall be limited to 5 ft. All runs of flexible conduit shall be supported in accordance with NEC requirements.
33. Where underground conduits are to be concrete encased, Contractor shall provide #4 rebar equally space for full length of concrete encasement. Rebar shall be parallel to conduit. Provide number of rebar as indicated on project drawings.

B. Underground Handholes and Boxes
1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
2. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
4. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.
5. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

+ + END OF SECTION + +

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SECTION 16131

BOXES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Outlet and junction boxes shall be furnished and installed where indicated on the Contract Drawings, and\or as required by the work in accordance with the NEC.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Boxes – "Queen," "Wiegmann," "Appleton," "Raco," "Bauers," "Crouse-Hinds," "Hoffman," "Robroy Industries," "Cloud Concrete Products," "Spring City," "Carlon," "Sedco," or equal.

2.2 GENERAL

A. All junction and/or pull boxes for dry (non-corrosive) areas shall be of code gauge sheet metal construction, of the inside dimensions as required by code, with covers.

B. Junction and/or pull boxes for wet or damp locations shall be cast metal, rust and corrosion resistant (NEMA 4X), with at least 5-1/2 full threads for each (bossed) conduit opening, and shall be suitable for flush or surface mounting as required with drilled external, cast mounting extensions (bossed to provide at least 1/8" between back of box and mounting surface for drainage). Box covers shall be hinged or cap screw retained as required, of the same material as the box and provided with stainless steel (rustproof) hardware.

C. Junction boxes for out-of-doors use, not mounted in concrete may be sheet metal (NEMA 4X), waterproof, rustproof, rain and sleetproof, with hinged covers and latches and provided means of locking by means of keyed locks, tamper-resistant screws or padlocking as required and with clamping cap-screws top and bottom door edges to provide firm contact with gasketing. All gaskets shall be molded (unbroken) neoprene or butyl rubber.

D. NEMA 4X junction and/or pull boxes may be stainless steel, if called for on the Contract Drawings; or non-metallic or cast aluminum.

E. Underground junction or pull boxes shall be constructed of reinforced concrete cast-in-place or pre-fabricated as detailed on the Contract Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION, APPLICATION, AND ERECTION

A. General
   1. Outlets shall be installed in the locations shown on the Contract Drawings. The Contractor shall study the general building plans in relation to the space surrounding each outlet, in order that his work may fit the other work required by these Specifications. When necessary, the Contractor shall relocate outlets so that when fixtures or other fittings are installed, they will be symmetrically located according to room layout and will not interfere with other work or equipment.
   2. All supports for outlet boxes shall be furnished and installed by the electrical trades.

B. Concealed Work
   1. All outlet boxes shall be standard galvanized steel type at least 12 inches deep, single or gang type of size to accommodate devices shown. Exceptions shall be noted on the Contract Drawings.
   2. Standard deep type outlet boxes (concrete rings with appropriate covers) shall be used in floor slab construction so concealed conduits entering sides of boxes can clear reinforcing rods.
   3. Outlet boxes for concealed telephone and signaling systems shall be the 4-inch square type, unless otherwise noted or required by the telephone company.
   4. Boxes for use in masonry construction shall be 22 inches deep for 4-inch block and 32 inches deep for 6- and 8-inch block. Through wall boxes are prohibited for outlets opposite each other.

C. Exposed Work
   1. Outlet or junction boxes for use with exposed steel conduit shall be cast steel. In dry areas, sheet steel with rounded corners, made for the purpose.
   2. Outlet or junction boxes for use with exposed aluminum conduit shall be copper free, cast aluminum type.
   3. Outlet or junction boxes for use with exposed PVC conduit shall be PVC.

D. Pull Boxes
   1. Pull boxes for exterior underground work are shown on the Contract Drawings and are the minimum number required. Others may be added at the Contractor's option, but no extra pay shall be allowed. Interior pull boxes are not shown but shall be used as needed. Pull box types are as follows:
      a. Exterior – Per detail on the Contract Drawings.

b. Interior – Interior pull boxes in dry areas shall be of code gauge steel of not less than the minimum required by the NEC and shall be provided with hinged covers. In wet areas or pipe galleries, they shall be rated watertight, of stainless steel, cast aluminum, PVC, fiberglass, or equal. Hardware shall be stainless steel.

E. Openings in Electrical Boxes

1. All openings in electrical equipment, enclosures, cabinets, outlet and junction boxes shall be by means of welded bosses, standard knockouts, or shall be sawed, drilled, or punched with tools specially made for the purpose. The use of a cutting torch is prohibited. Unused openings shall be plugged per the NEC.

+ + END OF SECTION + +

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SECTION 16140

WIRING DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Wiring devices shall be installed where indicated on the Contract Drawings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. "Hubbell," "Wiremold," "P&S," "Leviton," "Daniel Woodhead," or equal.

2.2 EQUIPMENT

A. General
   1. Sump pumps shall be equipped with the proper cord and plug for receptacles.
   2. Switch and receptacles for sump pump motors shall be rated at 20 amps at 125 volts and shall be equipped with a manual motor starting switch in lieu of toggle switch, as specified elsewhere this division.

B. Receptacles
   1. Twin-convenience - outlet (interior) – "Hubbell" Cat. No. 5362GRY, or equal.
   2. Twin-convenience - outlet (exterior) – "Hubbell" Cat. No. 5362GRY, with Taymac Corporation or Intermatic, Inc., safety outlet enclosure.
   3. Special purpose outlet - Per equipment requirements.
   4. Single receptacle for sump pump - 20A/125 VAC – "Hubbell" Cat. No. 2310, or equal.
   5. Ground fault interrupting receptacles shall be required where shown on the Contract Drawings, and shall be indicated by the abbreviation "GFI" beside the circuit symbol on the Contract Drawings. They shall be rated 20 amps (125 volts) and shall be of the duplex, feed through type, capable of protecting all downstream receptacles on the same circuit. They shall be UL listed and interrupt the current between 4-6 milliamps of ground fault leakage. Appropriate plates shall be furnished and installed. The 20 ampere rating shall apply not only to device internals but to the faceplate as well. Device shall be "Hubbell" Cat. No. GF5362GRY, or equal.

C. Plates and Covers

1. Furnish and install plates of the appropriate type and size for all wiring and control devices, signal and telephone outlets.
2. All plates on surface mounted boxes shall be of 302 stainless steel (nonmagnetic) with rounded or beveled edges, except in pump rooms, pipe galleries, and pipe trenches, then weatherproof covers shall be installed. All plates on flush mounted boxes shall be stainless steel. All device plate screws shall be stainless steel with countersunk heads. Plates shall be installed vertically and with an alignment tolerance of 1/16 inch. Device plates shall be of the one-piece type, of suitable shape for the devices to be covered. Plates shall have a smooth finish with no crevices to collect dirt. Oversize plates are not acceptable.
3. Covers for boxes serving equipment where flexible conduit is to be tapped into cover plates shall be sheet metal drilled for conduit. Gaskets shall be required as well as all special adapters for mounting.

D. Wall Switches (Tumbler Type)
1. Single pole (interior) – "Hubbell" Cat. No. 1221GRY, or equal.
2. Single pole (exterior) – "Hubbell" Cat. No. 1222GRY, or equal, and Bryant 7420 or equal plate.
3. 3-way switches (interior) – "Hubbell" Cat. No. 1223GRY, or equal.
4 4-way switches (interior) – "Hubbell" Cat. No. 1224GRY, or equal.
5. Low voltage 3-position - "Hubbell" Cat. No. HBL1557GRY, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Wall Switches
1. Wall switches shall be mounted at a height as indicated in Section 16050, unless otherwise noted on the Contract Drawings.

B. Receptacles
1. Outlets shall be located as shown on the Contract Drawings. Where located in special interior finishes, they shall be properly centered. Boxes shall be of the type noted and accepted for the specific installation.
2. Furnish and install receptacle circuits where called for on the Contract Drawings and/or by these Specifications. Circuits shall be installed in conduit from panel to receptacle, with flush mounted boxes except as noted on the Contract Drawings.
3. Receptacles and lighting circuits shall not be combined on the same overcurrent device. For runs over 75 feet or for 30 amp receptacles, minimum wire size shall be AWG No. 10.
4. Receptacles for specific devices (i.e., sump pumps), shall be rated at the correct voltage and amperage for that unit.

5. The minimum free length of conductor at each box for the connection of a fixture, switch or receptacle shall be 8 inches. All connections shall be made mechanically and electrically secure.
6. Receptacles shall be duplex type, rated at 20 amps, 125 volts, gray colored, unless otherwise noted. Mounting height shall be as specified for low outlets in Section 16050, except in pipe galleries and pump rooms subject to floods, where they shall be medium height. All receptacles shall be of the grounding type.
7. Receptacles over workbenches or countertops or at medium or high mountings shall be mounted so that the grounding slot is below the neutral and hot. All other receptacles shall be mounted with the grounding slot above the neutral and hot.
8. Weatherproof receptacles, shall be weatherproof while in use. This requirement shall apply on all outdoor units and on others as indicated on the Drawings. To meet this requirement, appropriate safety outlet covers as manufactured by Taymac Corporation, Intermatic Guardian Series, or equal shall be utilized in these areas.
9. Wiring devices in wet locations shall bear a weather resistant mark per UL Listing.

+ + END OF SECTION + +

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SECTION 16145

LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope
   1. This section includes furnishing all labor, equipment, and materials for a complete and operational lighting control system.
   2. Extent of lighting control system work is indicated by drawings, and by the requirements of this section. It is defined to include low voltage lighting control panels, switch inputs, and wiring.
   3. Type of lighting control equipment and wiring specified in this section include the following:
      a. Low voltage lighting control panels, low voltage switches and accessories.

B. Related Sections
   1. Section 16120, Conductors and Cables
   2. Section 16130, Raceways
   2. Section 16131, Boxes
   3. Section 16140, Wiring Devices
   4. Section 16500, Lighting

1.2 QUALITY ASSURANCE

A. UL & ULc Approvals.
   1. The control panels shall be tested and listed under the UL 916 Energy Management Equipment standard and CSA C22.2 #205 by a nationally recognized testing laboratory.

B. NEC Compliance
   1. The control system shall comply with all applicable National Electrical Codes regarding electrical wiring standards.

C. NEMA Compliance
   1. The control system shall comply with all applicable portions of the NEMA standards regarding the types of electrical equipment enclosures.

D. Component Pre-Testing
   1. All control equipment shall undergo strict inspection standards. The equipment shall be previously tested and burned-in at the factory prior to installation.

E. System Checkout

1. A factory trained technician or factory authorized personnel or contractor shall functionally test the control system and verify performance after installation.

F. Manufacturer
   1. Manufacturer shall have a minimum of 20 years experience in control systems. Manufacturer shall provide off the shelf control product from its inventory. Control systems that require custom assembly and sizing shall not be acceptable.

1.3 SUBMITTALS

A. Product Data
   1. Submit manufacturer's data on lighting control system and components.

B. Shop Drawings
   1. Submit drawings of lighting control panel and accessories including, but not necessarily limited to the low voltage relay panels, power wiring and switch inputs.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Greengate ControlKeeper as manufactured by Cooper Controls, Inc. or approved equal.

2.2 MATERIALS AND COMPONENTS

A. System Description
   1. The lighting control system shall consist of low voltage relay control panels with 64 programmable switch inputs and shall offer 48 control relays.
   2. Each low voltage lighting control panel shall be microprocessor controlled with a touch screen interface display. The touch screen shall provide relay status information viewable through a protected windowed enclosure. All local programming shall be permissible through the self-prompting touch screen.
   3. Programmable intelligence shall include Time-Of-Day control, 32 holiday dates, warn occupants of an impending off, timed inputs, preset control, auto daylight savings, astronomical clock w/offsets, local control, digital switches and network overrides.
      a. TOD: 64 Time-Of-Day/holiday schedules for 365 day programming
      b. Holidays: 32 holiday dates
      c. Warn Off: Flash lights and provide an extra 1 second to 99 minutes of illumination

d. Preset: Pre-programmed switch patterns
e. Timed Inputs: Switch input timers 1-999 minutes
f. Timed Overrides: Timed override from the touch screen 1-999 minutes, resumes to normal schedule
g. Local Control: From integral touch screen & local switch
h. Astronomical: Longitude and latitude input with sunset-sunrise
i. Clock: Offset to customize outdoor lighting
j. Auto Daylight Savings Adjust: Automatically adjusts the clock at the appropriate dates, selectable
k. Priorities: Establishes a hierarchy for inputs and network control commands
l. Masking: Provides permission orientation to switch inputs and network commands thereby ensuring building lighting control integrity
m. Soft-Linking: Group linking for rapid programming
n. Global Linking: Each panel shall provide 64 addressable groups for network linking of control commands
o. Analog Inputs: Four analog inputs

4. The control panel shall be capable of self-determining what relay type is in each relay location. The relays may be designated in software as Normal, Inverted, Sentry or Phantom to allow various program options. The controller shall be capable of reporting whether the relays are overridden via software, override switches, or via on board hardware override. Relay status shall not only disclose commanded relay status but next scheduled state to occur.
5. Each control panel shall provide a Warn Off (flash the lights) to inform the occupants of an impending Off command. The Warn Off command shall provide adjustable time duration of 1 second to 99 extra minutes. The occupants may exit the premises with adequate lighting or cancel the Warn Off by overriding the lighting zone. This option occurs with all Off commands except local overrides.
6. The controller shall permit lighting to be overridden On for after hours use or cleaning. The controller shall provide optional switch timer assignments or timed overrides. The override choices for various relays shall provide special event occurrences and the controller shall return to the programmed state after the override event. Also, the controller shall provide priority and masking choices to customize the functions of switch inputs, thereby enabling switches to function differently at different times of the day to meet special facility operational requirements. These overrides shall be digital, network, or hard-wired inputs.
7. Programming the controller shall be through the local integral touch screen. Descriptive information shall assist the user to employ the system without a programming manual.
8. Priorities and/or Masking shall be assigned to inputs, telephone override, and global commands to insure building integrity. Priorities enable or disable the inputs based on user actuation of overrides. Masks shall permit: On only, Off only and On & Off control for intelligent after hours utilization

of the controlled facility based on Time-Of-Day scheduling in the controller.

9. The lighting control system may be fully programmed through PC programming software. Programming shall be permitted through a direct RS-232 connection, modem or TCP/IP.
10. The control system shall provide networking between lighting control panels. One network may support a maximum of 254 control panels. Panels shall permit data sharing for global control. All inputs (no limitation) are transferable over the network to create any switching pattern required. The maximum length of the lighting control network shall be 4000 feet. Repeaters are available to extend the network as needed. Networks that rely on a single time clock for system operation shall not be acceptable.
11. The lighting control system shall log all control events. The controller shall monitor all relay actuations, switch inputs and user intervention. Log reports shall be available for any duration of time the operator chooses through the integral touch screen or the Keeper Enterprise Software. Runtimes for each relay shall be available from the integral touch screen or the Keeper Enterprise Software.

B. Hardware Features
   1. Diagnostic Aids
      a. Each control panel shall incorporate diagnostic aids for confirmation of proper operation, or in case of failure these aids shall guide the individual in rapid troubleshooting of the system.
      b. The control panels shall employ both a backlit touch screen and LED's to indicate:
         1) POWER (LED)
         2) SYSTEM OK (LED)
         3) NETWORK COMMUNICATIONS (LED)
         4) ON/OFF STATUS of EACH RELAY (LED & touch screen)
         5) SYSTEM CLOCK and DATE (touch screen)
         6) PROGRAMMING CONFIRMATION (touch screen)
      c. Control systems that do not provide visual self-help diagnostics shall not be acceptable.
         1) Status Indication of Relays
            a) The system shall provide visible status indication of all relays through the window of each control panel. The visual indication shall disclose On/Off status and relay number. Systems that do not provide relay status while the enclosure door is closed shall not be acceptable.
            b) Relay status shall also be visible via actual indication on the relay card. The serial standard relay cards shall provide visual status of the relay state and also the override state. The relay status LED shall also provide indication to the user if the relay is in a hand actuation condition. Each serial standard relay card shall permit manual overrides for each individual relay. The serial latched relay card shall provide relay status and permit

hand actuation.

B. Operator Interface
   1. The control panel programming interface resides in firmware in the control panel. The programming interface shall consist of a circuit board mounted touch screen capable of linking switch inputs to relay outputs and schedule assignments. Systems that utilize blocking diode technology for relay assignments shall not be acceptable.
   2. The integral touch screen shall provide access to the main programming features. The touch screen shall permit the user to manually command any or all relays individually. Each panel shall control its own loads from internal memory. A control system that relies on a central control computer/processor or external time clocks shall not be permitted.

C. Overrides
   1. The controller shall provide timers for each override. Each override timer shall be capable of 0-999 minutes. Software shall enable or disable overrides based on Priorities, Masks or Time Of Day scheduling.
      a. Digital Switch (Digita™)
         1) The lighting controller shall support digitally addressable LED annunciated switches. The maximum total number of digital switches that may exist on the lighting control network is 16,256. Each Subnet shall support 64 buttons. The digital switch network requires CAT 5 cable between switches. The digital switches shall control any relay group combination on the PCI-Net lighting control network. Data communications status feedback for system checkout and troubleshooting (transmit and receive — > LED'S) shall be visible on both the controller and interface.
         2) The digital switch configuration system shall permit custom labeling for multiple button switch locations. The digital switch configuration shall be Decora® form and function.
      b. Dry Contact Inputs
         1) The control system shall permit 32 dry contacts inputs for override purposes. Momentary 3 wire or 2 wire (toggle) inputs shall be supported. Maintained contacts shall be supported as 2 wire (SPST) inputs. Inputs shall be dry contacts (24 VDC @ 12 ma. internally supplied to the inputs). The 24 VDC power supply is provided with an auto-resettable fuse. Should an inappropriate electrical connection be made the design will protect the board and switches until the fault is removed. Any switch input shall be software linked to any number of relays for override control. The control panel shall have dry contact inputs on the logic board. Control systems that utilize separate accessories to allow for dry contact switches shall not be acceptable. Control systems that do not supply both digital switches and analog switches from the same controller shall not be permitted.
      c. Network Overrides

1) The controller shall accept network commands issued from other inputs or controllers on the network. The controller shall provide this feature without the need to add extra equipment to the controller. Network overrides can be issued from the Telephone Interface Module (TIM), Modbus® Gateway, DMXGateway, Photocells, Motion Sensors, Digital or Dry Contact Switches, or other controllers. Lighting systems that need to add extra equipment to receive network overrides are not acceptable.

D. Service Override & Priority Override
   1. The control panel shall provide a three position master-service override for the control unit. The service override shall not be accessible from the exterior. Systems that provide a service override on the exterior of the controller shall not be acceptable.
   2. The master service override provides a single three-position switch with the option of All Off, Auto, and All On, respectively. This master switch shall operate all of the relays in the controller. This switch shall override and supersede all commands from the logic board when the switch is in the All On or All Off position. The master switch shall function to override all the relays should the logic board programming differ from the space function.
   3. The system shall report all master service overrides to the controller and shall be accessible via network query. Systems that cannot determine when the service override is in use shall not be acceptable.
   4. The system shall remember the last command to the individual relays. Upon returning the master override switch to the Auto position, the relays shall return to the most recent command state. This will occur even if the last command happened during the master override condition.
   5. Additionally, the system shall provide external priority override for the entire panel. Through an externally maintained contact the override card shall place the panel in a priority state. This external contact will supersede any other programmed state and will command all the relays ON or OFF depending on operational choice. This priority state will continue until the external contact is removed. Once the external override is removed the control panel will return the relays to the appropriate programmed state.

E. Relays
   1. The controller shall come standard with electrically held 20amp 120/277VAC relays. The wire terminations shall be able to accept 10AWG. Relays must be specified Normally Open or Normally Closed. Relays that are latched or mechanically held are not acceptable. The relays shall be rated for 10 million mechanical operations.
      a. Serial Two Pole Relay Card (sTPRC-NO/NC)
         1) The controller shall provide an option for two pole relay control. The Two Pole Relay Card shall offer the feature of controlling two pole voltages such as 208, 240, and 480VAC in a Normally Open or Normally Closed configuration. This relay card shall also provide visual indication of relay status. The wire

terminations shall be able to accept 6 AWG wire. Two pole modules require two relay locations for a maximum of two - two pole relays per card. All Two Pole Relay Module components shall be warranted for 10 years. Systems that do not offer a limited 10-year warranty on all installations are not acceptable.

b. High Voltage Barriers

1) The controller shall provide as an option the ability to provide a barrier for either voltage separation or emergency circuit separation. The barrier shall be painted red to denote the difference. Systems that do not provide voltage separation are not acceptable.

F. RS-232 Port

1. The controller shall provide an RJ-12 connection for RS-232 communications. Programming shall be permitted through either a local connection or remotely through a modem. The Keeper Enterprise software accessory includes a six wire communication cable to connect to the controller. Systems that do not include an on-board RS-232 port for communications are not acceptable.

G. RS-485 Network

1. The controller shall be able to communicate to other controllers on a daisy chain twisted pair of wires. The RS-485 network shall be referred to as the PCI-Net and shall support 254 controllers with a maximum distance of 4000 feet. Each controller shall be optically isolated on the PCI-Net. The networked controllers shall provide optical isolation between controller power supplies for true electrical isolation (communication grounds are 100% isolated). CAT-6e or Belden #9841 shall be approved for network wiring.

H. Modular Design

1. The control system shall employ all modular connectors to avoid repeat wiring in case of component failure. The system CPU board shall be mounted on quick release hinge pins that shall permit an entire change out of the controller in less than 1 minute. All connections for the dry contact inputs shall incorporate modular connectors. The relay board shall be modular and designed for rapid field replacement or upgrading. Systems that do not employ modular connectors shall not be acceptable.

I. Memory Back-up

1. The system shall utilize a memory back-up device that is system integrated and shall be non-serviceable. The data in Flash RAM shall be protected against power interruptions for the life of the product. The power interrupt protection circuit shall be entirely maintenance-free.

J. Multi-tapped Transformer

1. The control panel shall incorporate the use of a multi-tapped transformer.

The panel shall not require specification of voltage for each control location. The voltages of 120 & 277 VAC shall be available with each control panel.

K. Lockable Enclosure
   1. Each control panel shall be enclosed in a lockable NEMA class 1 enclosure. The enclosure shall be manufactured out of 1/16" steel and shall provide pre-punched knockouts for efficient installation.

L. Enclosure
   1. The low voltage controller shall exist in three sizes of relay enclosures. The enclosure maximum sizes shall be either 16, 32 or 48 relays per cabinet. The 16-size will employ four relay cards and the 32-size will utilize 8 relay cards and the 48-size relay cabinet shall communicate to 12 relay cards. Relays shall be provided in groups of four relays per card.

M. Keeper Enterprise Software
   1. The PC based interface software accessory provides access to lighting control system files within a Microsoft® Windows® environment.
   2. The Keeper Enterprise software shall support Windows® 2000, Windows® XP and above. The optional software package shall allow individual and network panel programming to be executed locally, via direct connection or remotely through a TCP/IP connection or modem. The central programming software shall permit the user to modify the control panel programming or configuration in an "OFF-LINE" mode. This software package shall store all programmed data and archive for future use. Systems using third party software are not acceptable. Systems that are not capable of creating program backups are not acceptable.
   3. The following features shall be standard in the PC based software:
      a. Standard Software Features:
         1) Real Time Relay Status Monitoring
         2) Alpha-Numeric Descriptors
         3) Communications: Direct, Network, TCP/IP and Modem
         4) Network Status Indication
         5) Global Software Modifications
         6) Manual Relay Commands
         7) Remote Pattern Commands
         8) Preset Options
         9) User Management – Password protection, and privilege modification for multi-user security.
         10) Logging of Controller Actions (switch inputs, TIM commands, & relay actuations)
         11) Remote Commander –(entire network global commands from one screen)
      b. File Maintenance
         1) Archive Programs
         2) Data Base Restoration
         3) Uploading and Downloading of Programs

4) Snap Shots indication of changes and flawless panel restoration.
5) Software package shall permit the PC to be utilized for other functions (i.e. word processing, database, & etc..) besides lighting control. Systems that require an "on-line" dedicated computer for control system operation shall not be acceptable.

N. System Management Software Accessories
1. System Management Software Accessories require the Ethernet Interface Module (EIM) accessory, connection to the building LAN and Windows® 2000, Windows® XP or above operating system.
a. VisionTouch®
1) The lighting zones may be controlled through a graphical representation software package called VisionTouch®. The software permits up to 255 floors or site plans to be illustrated for intuitive control. The software provides real-time feedback to the operator of network control overrides. The software shall be accessible through an Ethernet network permitting more than one location control access to the site. The software shall accept AutoCAD® drawing files to reduce programming set up of the control software. VisionTouch®requires the PCI Ethernet Interface Module.
b. VisionSwitch®
1) A lighting control tool which, when integrated on a computer desktop, shall employ Ethernet communications and shall control up to four load-groups per computer desktop. Each load-group shall span several panels and relays. VisionSwitch® requires the PCI Ethernet Interface Module.

O. Network Hardware Accessories
1. The ControlKeeper® TouchScreen has several hardware accessories that may be utilized to enhance your lighting control application.
a. Ethernet Interface Module (EIM)
1) Internet Connection Specifications: The control system accessory provides easy access to control panels over a TCP/IP connection by converting sent information into RS-232 communication capable information. This unit operates on standard 110VAC. Manufacturer shall provide proper cabling from controller to Ethernet Interface Modules. RJ-45 connections are the responsibilities of others.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION AND DOCUMENTATION

A. Installation
1. The control system shall be installed and fully wired as shown on the plans by the installing contractor. The contractor shall complete all electrical

connections to all control circuits, and override wiring.

B. Documentation
   1. The contractor shall provide accurate "as-built" drawings to the owner for correct programming and proper maintenance of the control system. The "as-builts" shall indicate the load controlled by each relay and the relay panel number.

C. Operation and Service Manuals
   1. The factory shall supply all operation and service manuals.

3.2 PRODUCT SUPPORT AND SERVICE

A. Factory Support
   1. Factory telephone support shall be available at no cost to the owner. Factory assistance shall consist of solving programming or application questions concerning the control equipment.

3.3 SYSTEM DELIVERY AND ACCEPTANCE

A. Delivery
   1. The contractor is responsible for complete installation of the entire system according to strict factory standards and requirements. The following items shall constitute factory standards and requirements:
      a. All system equipment shall operate in accordance with specification and industrial standard procedures.
      b. An operational user program shall exist in the control system. The program shall execute and perform all functions required to effectively operate the site according to the requirements.
      c. Demonstration of program integrity during normal operation and pursuant to a power outage.
      d. Contractor shall provide a minimum of two training hours on the operation and use of the control system. Additional support services shall be negotiated between the contractor and the building owner or manager.

3.4 WARRANTY

A. Warranty
   1. Manufacturer shall supply a 3-year warranty on all hardware and software. A limited 10-year warranty shall be provided on all relay cards. These warranties will be in effect for all installations. Systems that provide special warranties based on installation shall not be acceptable.

+ + END OF SECTION + +

SECTION 16150

WIRE CONNECTIONS AND CONNECTING DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Wire connection and connecting devices shall be as herein specified.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Connectors, Lugs, etc. – "T & B", "Anderson", "Burndy", or equal.

B. Termination and splice connectors – "3M Scotchlok", "Anderson", "T & B", "Burndy", or equal.

2.2 MATERIALS

A. Wire Splicing and Terminations (600 Volts and Below)
   1. Electrical Terminal and Splice Connectors (#22 - #4 AWG)
      a. Terminals and splice connectors from #22 - #4 AWG shall be compression types with barrels to provide maximum conductor contact and tensile strength. Performance, construction, and materials shall be in conformance with UL standards for wire connectors and rated for 600 volts and 105 degrees Celsius.
      b. Connectors shall be manufactured from high conductivity copper and entirely tin plated. Terminal barrels shall be serrated on the inside surface and have a chamfered conductor entry. Terminals shall have funnel entry construction to prevent strand fold-back. All barrels shall be brazed seam or seamless construction.
      c. Spade type terminals shall be sized for the appropriate stud and shall be locking type that snap firmly onto studs with a close fit for maximum retention. Spade type terminals shall be insulated with an insulation suitable for maintaining a high dielectric strength when crimped and be made form nylon, PVC, or equal.
   2. Electrical Lugs and Connectors (#6 AWG - 1000 Kcmil)
      a. Lugs and splice connectors from #6 AWG - 1000 Kcmil shall be compression types with barrels to provide maximum conductor contact and tensile strength. They shall be manufactured from high conductivity copper and entirely tin plated. They shall be crimped with standard industry tooling. The lugs and connectors must have a current carrying capacity equal to the conductors for which they are

rated and must also meet all UL requirements. All lugs above 4/0 AWG shall be 2 hole lugs with NEMA spacing. The lugs shall be rated for operation through 35 KV. The lugs shall be of closed end construction to exclude moisture migration into the cable conductor.

3. Twist-on Wire Connectors (#22 AWG - #10 AWG)
   a. All twist-on wire connectors must have a corrosion resistant spring that is free to expand within a steel jacket. The steel jacket must be insulated with a flexible vinyl jacket capable of withstanding 105 degrees Celsius ambient temperatures and of sufficient length to cover wires that are inadvertently overstripped.
   b. Each connector size must be listed by UL for the intended purpose and color coded to assure that the proper size is used on the wire combinations to be spliced. The connectors must be compatible with all common rubber and thermoplastic wire insulations.
4. Solderless/re-usable lugs shall be used only when furnished with equipment such as control panels, furnished by others, where specification of compression type lugs is beyond the Contractor's control. In the event their use is necessary, the Contractor shall be responsible for assuring that they are manufactured to NEMA standards, with proper number and spacing of holes and set screws.

PART 3 - EXECUTION

3.1 INSTALLATION, APPLICATION, & ERECTION

A. Insulation of Splices and Connections
   1. Connections/splices with a smooth even contour shall be insulated with a conformable 7 mil thick vinyl plastic insulating tape which can be applied under all weather conditions and is designed to perform in a continuous temperature environment up to 105 degrees Celsius. The tape shall have excellent resistance to abrasion, moisture, alkalies, acids, corrosion, and varying weather conditions (including sunlight). The tape shall be equal to Scotch 33+ and shall be applied in conformance with manufacturer's recommendations. In addition, it shall be applied in successive half-lapped layers with sufficient tension to reduce its width to 5/8 of its original width. The last inch of the wrap shall not be stretched.
   2. Connections/splices with irregular shapes or sharp edges protruding shall be first wrapped with 30 mil rubber tape to smooth the contour of the joint before being insulated with 33+ insulating tape specified in the previous paragraph. The rubber tape shall be high voltage (69 KV) corona-resistant based on self-fusing ethylene propylene rubber and be capable of operation at 130 degrees Celsius under emergency conditions. The tape must be capable of being applied in either the stretched or unstretched condition without any loss in either physical or electrical properties. The tape must not split, crack, slip, or flag when exposed to various environments. The tape must be compatible with all synthetic cable insulations. The tape must

have a dissipation factor of less than 5 percent at 130 degrees Celsius, be non-vulcanizing, and have a shelf life of a least 5 years. The rubber tape shall be applied in successive, half-lapped wound layers and shall be highly elongated to eliminate voids. Other manufacturer's recommendations on installation shall be adhered to. The rubber tape shall be equal to Scotch 23 or 130C electrical splicing tape.

3. Splices made in wet or damp locations shall be made submersible and watertight with special kits made for the application and compatible with type of cables employed.

B. Connection Make-up

1. Connections of lugs to bus bars, etc., shall be made up with corrosion resistant steel bolts having non-magnetic properties with matching nuts, and shall utilize a Belleville spring washer (stainless steel) to maintain connection integrity. Connections shall be torqued to the proper limits. Prior to bolting up the connection, electrical joint compound shall be brushed on the contact faces of the electrical joint.
2. All motor lead connections shall be made up to match the type of lead furnished on the motor. If the lead is not lugged, then twist-on wire connectors may be used. To prevent possible vibration problems, twist-on connectors shall be taped after installation.
3. All lugged motor lead connections (excluding motors over 200 horse-power) shall be made up using ring tongue compression lugs with proper size stainless steel nuts and bolts. Belleville type spring shall be used to maintain tension on the connections. The connections shall then be insulated using the procedure described for irregular shapes, utilizing rubber tape in conjunction with vinyl electrical tape.
4. At the time of final inspection, the Engineer may request the Contractor to disassemble 3 randomly selected motor lead connections in the Engineer's presence, to assure conformance with these Specifications.
5. The Contractor shall include all necessary tools, materials, and labor in his bid for disassembly of the connections and for remaking them with new insulating materials after inspection.

+ + END OF SECTION + +

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SECTION 16170

SAFETY SWITCHES

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. Provide horsepower-rated, quick-make, quick-break, safety switches provided with the number of poles and fuses as required.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS/EQUIPMENT

A. Safety switches shall be as manufactured by Siemens, Square D Company, Eaton, or equal.

B. All switches shall be heavy-duty type with Class R fuse clips.

C. Switches shall have arc shields, shall be of enclosed construction and fusible or non-fusible as indicated. Switches shall be rated for either 250-volt AC or 600-volt AC service as required.

D. Safety switches for all part-winding or two-speed motors requiring remote disconnect to be similar to Square D Series HLL-660, six-pole.

E. All switches shall be capable of interrupting locked rotor current of motor which it serves.

F. Enclosures shall be NEMA-1 for interior use and NEMA-3R for exterior use unless noted otherwise.

G. Provide dual-element Bussman type FRN (250 volt) or type FRS (600 volt) fuses for any fusible safety switch serving a motor circuit.

H. For non-motor loads, provide dual element Bussman type LPN (250 volt) or type LPS (600 volt).

I. All switches shall be capable of being padlocked in either the “On” or “Off” position.

J. Safety switches shall be provided with auxiliary contacts where indicated on Contract Drawings.

K. Safety switches shall be UL listed and shall conform to NEMA Standards. NEMA 4X enclosed safety switches where called for shall be stainless steel.

L. NEMA 1 enclosed switches shall be phosphate coated as equivalent, code gauge steel with baked enamel finish.

M. Double throw fused/non fused safety switches where required, shall be as specified on the Contract Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide non-fusible switches at remote motor locations (raintight where required) as indicated on drawings.

B. Provide fusible disconnects at package A/C units, fused as specified on unit nameplate.

C. Mount switches to walls or to equipment enclosures with a minimum of 4 bolts using toggle anchors for masonry construction, Phillips “Red Head” anchors for poured concrete construction and bolts, jumbo washers, lock washers and nuts for equipment enclosure mounting.

D. All safety switches to be identified with nameplates per Section 16075.

+ + END OF SECTION + +

SECTION 16220

MOTORS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Motors are to be furnished with driven equipment except where otherwise noted on the Contract Drawings or elsewhere in this Division of the Specifications. All motors shall conform to the following Specifications and any special requirements of the driven equipment. Special requirements of the driven equipment shall take precedence over these Specifications should a discrepancy occur. Starting torque and slip ratings shall conform to the requirements of the driven equipment. All motors 15 horsepower and larger (230 volt) or 25 horsepower and larger (480 volt) shall be started via autotransformer reduced voltage starters unless otherwise noted on the Contract Drawings.

B. Polyphase motors shall be of the squirrel cage induction type and single phase of the capacitor start-induction run type except as otherwise noted. Conduit boxes shall be tapped for the size conduit shown on the Contract Drawings.

C. All motors shall be manufactured and installed in accordance with applicable NEMA standards and NEC provisions, latest revisions.

1.2 DELIVERY, STORAGE, & HANDLING

A. All electrical motors shall be protected against the accumulation of moisture, dust and debris and physical damage during the course of installation of the job.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Motors – “General Electric”, “Westinghouse”, “U.S. Motors”, “Gould Century”, “Lincoln”, “Baldor”, “Marathon”, “Reliance”, “Magnatek”, “Siemens”, or equal.

2.2 EQUIPMENT

A. Motors 200 Horsepower and Under for Service Under 600 Volts
   1. Ratings and Electrical Characteristics
      a. Time: All motors shall be rated for continuous duty.

b. Temperature: Based on NEMA standards for a maximum ambient temperature of 40 degrees Celsius and an altitude of 3,300 feet or less, according to service factor and insulation class employed.

c. Voltage: All single phase motors shall be rated 115/208/230 volts and all polyphase motors 230/460 volts. All motors shall be capable of normal operation at balanced voltages in the range of 10 percent from rated winding voltage.

d. Frequency: All a-c motors shall be rated for 60 Hz. operation. All motors shall be capable of normal operation at frequencies 5 percent above or below the nominal rating of 60 Hz.

e. Horsepower: Horsepower of the motors shall be as given in the Specification Division on the driven equipment or as shown on the Contract Drawings. In many cases, the horsepower specified is a minimum requirement and certain alternate manufacturers may require larger horsepower motors. The larger motor shall be furnished at no extra cost to the Owner.

f. Locked Rotor Current: Locked rotor current shall be in accordance with NEMA standards.

g. Efficiency and Power Factor: Efficiency and power factor shall be given consideration during Shop Drawing review. The ratings at full, :, and 2 load shall be compared to similar motors manufactured by acceptable suppliers listed in these Specifications. Excessive variation shall be considered grounds for rejection.

h. Speed: Synchronous speed of motors shall correspond to standard NEMA ratings. Actual speed shall be as given in the Specification Division on the driven equipment. Slip shall not exceed 5 percent at full load.

i. Service Factor: The service factor shall be 1.15 unless VFD driven, then 1.0 service factor and suitable for VFD driven operation.

j. Insulation Class: Insulation shall be NEMA Class B, except as otherwise noted. Motors to be operated at variable speed shall be Class F. Class F insulated motors shall operate at a Class B rise at nameplate horsepower loading.

k. Design Level: Motors shall be NEMA design B, except as otherwise noted.

l. Enclosure: Motors for process equipment 2 HP and smaller shall be totally enclosed. All motors for process equipment larger than 2 HP shall be TEFC (totally enclosed fan cooled), suitable for use indoors or outdoors, except as otherwise noted. Totally enclosed non-ventilated (or air-over) motors may be used for ventilators and other auxiliary equipment that by virtue of the load are provided with more than adequate ventilation. ODP (open dripproof) motors may be used for ventilators where the motor is outside the air stream yet still protected from the weather. Division 15 of the Specifications and the HVAC Contract Drawings will detail the type of enclosure required for ventilators. Motors used in classified atmospheres shall be properly

rated for that hazard. Motors for potable water wells shall be water-filled/lubricated.

m. Frame Size: Frame designations shall be in accordance with NEMA standards.

n. Winding Overtemperature Sensors: All motors 15 horsepower and over shall be provided with motor winding thermostats. The devices shall be hermetically sealed, snap-acting thermal switches, actuated by a thermally responsive bi-metallic disk. A minimum of 1 per phase is required, with switches wired into the control circuit of the starter, to provide deenergization should overheating threaten. All submersible motors shall be equipped with motor winding thermostats.

o. Motors for use with variable frequency drives shall be labeled "Inverter Duty".

2. Mechanical Characteristics

a. Integral Horsepower Motor Construction

1) Motor frames for horizontal motors shall be cast iron, heavy fabricated steel, or cast aluminum (alloy 356 or 360). A steel insert ring shall be set into the aluminum alloy endshield when cast to minimize wear of the bearing support. Aluminum alloy motors shall not be used in areas where exposed to chlorine gas.

2) Motor frames for vertical motors shall be cast iron, heavy fabricated steel, or extruded aluminum (alloy 6063-T4 or 6063-T6). Endshields for vertical motors must be cast iron.

3) If an aluminum frame is used, the endshields and/or all other steel hardware must be plated with zinc or cadmium and coated with grease before assembly to minimize the galvanic action between the steel and aluminum.

4) Motor frames and endshields shall be of such design and proportions as to hold all motor components rigidly in proper position and provide adequate protection for the type enclosure employed. Lifting lugs of all motors shall conform to NEMA standards.

5) Windings shall be random or form wound, adequately insulated and securely braced to resist failure due to electrical stresses and vibration. If the windings are aluminum, there shall be a cold welded aluminum-copper transition joint at the termination of the windings to permit the use of standard copper to copper connection techniques by the electrician and to prevent galvanic action between the copper power wires and the aluminum windings.

6) The motor shaft shall be made of high grade machine steel or steel forging of size and design adequate to withstand the load stresses normally encountered in motors of that particular rating. Bearing journals shall be ground and polished.

7) Rotors shall be made from high grade steel laminations adequately fastened together and to the shaft. Rotor cage

windings may be cast aluminum of bar type construction with brazed end rings.

8) Integral horsepower motors shall be equipped with cone, roller, or ball bearings made to AFBMA standards, Grade 1 and shall be of ample capacity for the motor ratings. The bearing housing shall be large enough to hold sufficient lubricant to minimize the need for frequent relubrication (ten years normal operation without lubrication), but facilities shall be provided for adding new lubricant and draining out old lubricant without motor disassembly. The bearing housing shall have long, tight running fits or rotating seals to protect against the entrance of foreign matter into the bearings or leakage of lubricant out of the bearing cavity.

9) See the specification division relating to each piece of motor driven equipment for additional motor requirements to those listed above.

b. Fractional Horsepower Motor Construction

1) Motor and shell shall be rigid welded steel designed to maintain accurate alignment of motor components and provide adequate protection. End shields shall be reinforced, lightweight, die cast aluminum. Windings shall be of varnish insulated wire with slot insulation of polyester film and baked on bonding treatment to make the stator winding strongly resistant to heat, aging, moisture, electrical stresses, and other hazards. Motor shafts shall be made from high grade, cold rolled, shaft steel with drive shaft extensions carefully machined to standard NEMA dimensions for shaft coupled drive connection. Bearings shall be carefully selected precision ball bearings with extra quality, long life grease and large reservoir providing 10 years normal operation without relubrication, AFBMA Grade 1.

3. Tests, Nameplates, and Shop Drawings

a. Tests

1) Tests shall be required on integral horsepower motors only. A factory certified test report of "electrically duplicate motors previously tested" shall be supplied on all motors under 200 horsepower. The test shall be certified by the factory and shall contain a statement to the effect that complete tests affirm the guaranteed characteristics published in the manufacturer's catalogs or descriptive literature.

2) Tests will be in accordance with IEEE test procedures.

b. Nameplates

1) Each motor shall have a permanently affixed nameplate of brass, stainless steel, or other metal of durability and corrosion resistance. The data contained on the nameplate shall be in accordance with NEMA standards.

c. Shop Drawings

1) Shop Drawings shall consist of motor dimensions, nameplate data from each motor and tests as outlined above. Also included shall be efficiency and power factor at 100, 75, and 50 percent load. Operation, maintenance, and lubrication information (including bearing catalog numbers) shall be submitted with Shop Drawings for review.

4. Efficiency Requirements

a. The following motor full load efficiency requirements shall be met as a minimum for totally enclosed 3 phase integral horsepower motors, per NEMA test methods:

Horsepower	**Nominal 3600 RPM (Minimum %)**	**Nominal 1800 RPM (Minimum %)**	**Nominal 1200 RPM (Minimum %)**
1	75.5	82.5	80.0
1.5	82.5	84.0	85.5
2	84.0	84.0	86.5
3	85.5	87.5	87.5
5	87.5	87.5	87.5
7.5	88.5	89.5	89.5
10	89.5	89.5	89.5
15	90.2	91.0	90.2
20	90.2	91.0	90.2
25	91.0	92.4	91.7
30	91.0	92.4	91.7
40	91.7	93.0	93.0
50	92.4	93.0	93.0
60	93.0	93.6	93.6
75	93.0	94.1	93.6
100	93.6	94.5	94.1
125	94.5	94.5	94.1
150	94.5	95.0	95.0
200	95.0	95.0	95.0

Open Motors where specified shall also comply with NEMA efficiency minimums.

b. Motors shall be energy efficient type to comply with requirements of the Energy Policy Act of 1992.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Installation of motors shall comply with motor manufacturer instruction's as well as applicable NEMA recommendations and requirements of the driven equipment OEM (original equipment manufacturer).

B. Motors shall be aligned to acceptable tolerances and shall not vibrate excessively.

C. Motors shall not be energized until they have been accepted by the OEM start up personnel.

+ + END OF SECTION + +

SECTION 16230

STANDBY POWER GENERATOR SYSTEMS - FIXED

PART 1- GENERAL

1.01 SCOPE OF WORK

A. This Specification covers the installation of two fixed emergency standby generator systems and their major items of auxiliary equipment to parallel the two generators to one power bus. The engine, generator, and all equipment that make up the standby generator systems shall be bid direct to each Contractor by the manufacturer or his authorized distributor maintaining a parts and service facility within 150 miles of the project location.

B. All materials equipment and parts comprising the units specified herein shall be new and unused, of current manufacture and of the highest grade. All equipment shall be free from all defects or imperfections.

C. Equipment specified in Section 16340 shall be furnished with the equipment specified herein, to be coordinated, installed, and tested as a complete functional system.

1.02 SUBMITTALS

A. The submittal shall include complete wiring schematics and interconnection diagrams identifying by terminal number each required interconnection between the transfer switch, emergency shutoff pushbuttons, engine control panel, etc. The submittal shall also contain complete descriptive literature on every piece of equipment, battery sizing calculations, and spare parts list.

1.03 GUARANTEE AND SERVICE AGREEMENT

A. Equipment furnished under this section shall be guaranteed against defective parts or workmanship for a period of five years from the date of field testing and acceptance by the Owner. The warranty shall include 24 hour parts and service from the manufacturer through the local distributor.

B. During the five year warranty period, the supplier of the generator and transfer switch package shall provide regular maintenance of the equipment in accordance with the manufacturer's published operation and maintenance manuals. Regular maintenance shall include, but not be limited to tune-ups and associated parts, fuses, filter replacements, spark plugs, clamps, and hoses. Regular fluid replacements including oil and coolants shall also be included. Any required

adjustments to the transfer switch and generator controls shall be included in the maintenance agreement.

C. After each maintenance or warranty site visit, a report shall be provided to the Owner outlining the maintenance performed, adjustments made, repairs or corrections, and a list of parts that were replaced during the site visit.

D. See General Requirements for general project warranty requirements.

1.04 TESTING

A. Generator Set:
   1. The generator sets shall receive the manufacturer's standard testing and a full load bank test on site. Prior to acceptance of the installation, the equipment shall be tested to show it will perform satisfactorily, including automatic starting, subject to full load test, and reset as required in these Specifications. The generator shall be tested under full load for a minimum of 60 minutes, and under 75% load for an additional 60 minutes. Prior to acceptance, any defects which become evident during this test shall be corrected by the manufacturer.

B. Paralleling Switchgear
   1. Interconnection to 2400 volt switchgear breakers, paralleling the two generators for fully automatic operation is the responsibility of the generator manufacturer. In addition, an operating test shall be simulated to verify that all of the equipment performs as described above. A certified test report shall be furnished by the manufacturer to show that the generator controls meets all requirements of these Specifications and that the operational requirements have been met.

1.05 START-UP

A. Generator Set:
   1. On completion of the installation, the initial startup shall be performed by a factory-trained representative of the engine supplier. At the time of startup, operating instruction and maintenance procedures shall be thoroughly explained to operating personnel. Installation, operating, and maintenance instruction books shall be submitted for the electric set and all auxiliary equipment in a 3-ring binder, at the time of submittal of descriptive literature, for review. The manufacturer's service representative shall be prepared to check phase rotation "by instrument", prior to start-up. It will not be allowed to isolate one motor on the generator and check its rotation to determine phasing.

PART 2- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Generators shall be manufactured by “Kohler”, “Caterpillar”, or equal.

B. Manufacturers for smaller components are listed under each component’s description.

2.02 GENERATOR SET

A. Rating:
   1. The standby generators shall be rated 2500 KW minimum each with fan for continuous service with normally varying loads during interruption of utility power - 0.8 power factor, 2400 volts, 3 phase 3 wire, 60 Hz. and shall have a maximum operating speed of 1,800 rpm.
   2. Ratings must be substantiated with manufacturer’s standard published curves. Special ratings for a particular application are not permitted. These ratings must reflect the net power available after deducting all engine driven accessories.

B. Engine:
   1. The 5822 cubic-inch displacement engine shall deliver 3675 hp at 1,800 rpm maximum and shall be full compression diesel type and of the 4 stroke cycle, turbo charged, intercooled. The engine and alternator shall be furnished to meet the SKVA requirement of 2926 KVA (for each unit) under 20% maximum voltage dip conditions.
   2. Engines shall be capable of normal operation on a commercial grade, No. 2-d domestic burner oil. The unit shall be furnished with filters for fuel, oil, and intake air. Air cleaner restrictor indicator shall be provided to indicate the need for maintenance of the air cleaner. A suitable lubrication oil cooler and transfer pump shall be furnished as part of the engine equipment. Lubricating oil for the unit shall be furnished by the engine manufacturer.
   3. The engine shall have an engine mounted radiator of sufficient capacity to maintain safe operating temperature at an ambient room temperature of 125°F. The engine shall be equipped with thermostats and a jacket water pump of sufficient capacity to overcome piping losses for the distances and heights shown on the Drawings. The system shall properly cool the engine with up to 0.5 H20 static pressure on the fan in an ambient temperature up to 105°F. The radiator shall be equipped with a core guard, fan guard, and flange for duct connection. Flexible hose connections shall be provided at the engine and radiator. The radiator and engine cooling system shall be filled with a 50 percent solution of ethylene glycol and water to prevent freezing. Electric set manufacturer shall furnish antifreeze prior to start-up.
   4. A critical silencer shall be furnished for the unit with a side inlet properly sized according to the silencer manufacturer’s recommendation for the

engines used. Mounting shall be as shown on the Drawings. A stainless steel flexible exhaust fitting shall be provided for mounting between the engine exhaust and exhaust pipe. The silencer system shall be of a type and size to ensure against loss of engine power due to excessive back pressure. The silencer shall be equipped with a condensate drain. A bird screen shall be welded into the end of the exhaust pipe which extends to the building exterior.

5. Safety shutoff alarms shall be provided for high water temperature, low oil pressure, engine overspeed, engine overcrank, and high lubricating oil temperature.
6. The engine assembly shall be mounted on a structural steel subbase and shall be provided with vibration isolators between the engine and the steel subbase or between the base and floor.
7. The engine and all accessories shall comply with all applicable portions of NFPA 37 "Stationary Combustion Engines and Gas Turbines", NFPA 30 "Flammable and Combustible Liquids Code" latest revisions, International Fire Code, as well as NFPA 31 "Installation of Oil Burning Equipment" latest revision.
8. The engine shall be equipped with an engine mounted thermal circulation type water heater to maintain engine jacket water at 90 degrees Fahrenheit in an ambient temperature of 30 degrees Fahrenheit. The heaters shall be 60 Hz. 208 volt a-c.
9. EPA certifications are currently required for generator sets. The level at which generators must be certified may be different at the time the project is awarded or equipment purchased than at the time these Specifications are written. The generator set for this project shall meet the current requirements at the time that the equipment is manufactured.
10. The unit shall be equipped with an electronic governor, capable of ±0.25% steady-state frequency regulation.

C. Generator:
   1. The alternator shall be salient-pole, brushless, 12-lead reconnectable, self-ventilated of drip-proof construction with amortisseur rotor windings and skewed stator for smooth voltage waveform. The insulation shall meet the NEMA standard (MG1-33.40) for Class H and be insulated with epoxy varnish to be fungus resistant per MIL 1-24092. Temperature rise of the rotor and stator shall be limited to 130°C. The excitation system shall be of brushless construction controlled by a solid-state voltage regulator capable of maintaining voltage within ± .25% at any constant load from 0% to 100% of rating. The regulator must be isolated to prevent tracking when connected to SCR loads, and provide individual adjustments for voltage range, stability and volts-per-hertz operations; and be protected from the environment by conformal coating.
   2. The generator set shall meet the transient performance requirements of ISO 8528-5, level G-3.
   3. The alternator excitation shall be of a permanent magnet exciter design.

4. The generator shall be inherently capable of sustaining at least 250% of rated current for at least 10 seconds under a 3-phase symmetrical short circuit without the addition of separate current support devices.

5. The alternator having a single maintenance-free bearing, shall be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.

D. Controller
   1. Standards:
      a. Control – The generator must meet NFPA-110 Level 1 requirements (1996 version) and shall have an integral alarm horn as required by NFPA.
      b. NFPA-99 and NEC shall also be accommodated.
      c. Set control shall be listed under UL 508.
   2. Applicability:
      a. For standardization purposes, the control described herein shall be available on generator sets 20kW and larger.
      b. The control shall be usable on 12- or 24-volt starting systems.
      c. Environment
         1) -40°C to +70°C operating temperature range
         2) 5-95% humidity, non condensing
      d. It shall be possible to mount the control on the generator set or remotely within 40 feet of the generator set. If mounted on the generator, the control shall be able to be mounted in any of 4 orientations for ease of viewing.
   3. Hardware Requirements:
      a. The control shall have a key operated run-off/reset-auto three-position selector switch.
      b. A controller mounted latch type emergency stop push button must be supplied.
      c. It shall be possible to adjust alternator output voltage at the control.
      d. Five indicating lights:
         1) system ready – green
         2) not in auto – yellow
         3) programming mode – yellow
         4) system warning – yellow
         5) system shutdown - red
      e. Lighted display with two lines of 20 alphanumeric characters for messages. Panel lights shall be supplied as standard.
      f. Sixteen position snap action sealed keypad for menu selection and data entry.
      g. For ease of use, an operating guide shall be on the controller faceplate.
      h. An audible alarm shall be supplied in the control.
   4. Control Functional Requirements:
      a. Field programmable time delay for engine start. Adjustment range, 0-

5 minutes in 1 second increments.

b. Field programmable time delay engine cooldown. Adjustment range, 0-10 minutes in 1 second increments.

c. It shall be possible to start the generator and run it at an idle speed during warm-up. The idle time shall be user adjustable. Engine cooldown at idle shall also be available.

d. Real time clock and calendar for time stamping of events.

e. Output with adjustable time for an ether injection starting system. Adjustment range, 0-10 seconds.

f. Output for shedding of loads if the generator reaches a user programmable percentage of its kW rating. Load shed shall also be enabled if the generator output frequency falls below 59 Hz (60 Hz system) or 49 Hz (50 Hz system).

g. Programmable cyclic cranking that allows up to six crank cycles and up to 45 seconds of crank time per crank cycle.

h. The capability to reduce controller current battery draw, for applications where no continuous battery charging is available, shall be provided. The controller vacuum fluorescent display should automatically be turned off after 5 minutes of no controller activity.

i. The controller firmware shall provide alternator protection for overload and short circuit matched to each individual alternator and duty cycle.

j. A ± 0.25% digital voltage regulator shall be incorporated into the controller software. No separate voltage regulator is acceptable. The digital voltage regulator shall be applicable on single or three phase systems.

k. It must be possible to exercise the generator by programming a running time into the controller.

5. Generator System Monitoring Requirements:

   a. All monitored functions must be viewable on the digital display.

   b. The following generator functions shall be monitored.

      1) all output voltages – single phase, three phase, line to line, and line to neutral, 0.25% accuracy
      2) all single phase and three phase currents, 0.25% accuracy
      3) output frequency, 0.25% accuracy
      4) power factor by phase with leading/lagging indication
      5) total instantaneous kilowatt loading and kilowatts per phase, 0.5% accuracy
      6) kVARS total and per phase, 0.5% accuracy
      7) kVA total and per phase, 0.5% accuracy
      8) kW hours
      9) a display of percent generator duty level – actual kW loading divided by the kW rating

   c. Engine parameters listed below shall be monitored:

      1) coolant temperature both in English and metric units
      2) oil pressure in English and metric units

3) battery voltage
4) rpm
5) lube oil temperature
6) lube oil level
7) crankcase pressure
8) coolant level
9) coolant pressure
10) fuel pressure
11) fuel temperature
12) fuel rate
13) fuel used during the last run
14) ambient temperature

d. Operational records since system start up shall be stored in the controller.
1) run time hours
2) run time loaded
3) run time unloaded
4) number of starts
5) factory test date
6) last run data including date, duration, and whether loaded or unloaded
7) kW hours

e. The following operational records shall also be available in a resetable form for maintenance purposes.
1) run time hours
2) run time loaded
3) run time unloaded
4) kilowatt hours
5) days of operation
6) number of starts
7) start date after reset

f. The controller shall store the last one hundred generator system events with date and time of the event.

g. For maintenance and service purposes, the following information shall be stored in the control and displayed on demand:
1) manufacturer's model and serial number
2) battery voltage
3) generator set kilowatt rating
4) rated current
5) system voltage
6) system frequency
7) number of phases

6. The control must be capable of detecting the following conditions, indicate if the condition will shutdown the generator or provide a warning, and annunciate the situation, using words and phrases, on the digital display.
a. Will cause system shutdown:

1) air damper tripped (if used)
2) customer programmed digital auxiliary input ON (any of the 21 inputs available)
3) customer programmed analog auxiliary input out of bounds
4) emergency stop
5) high coolant temperature
6) high oil temperature
7) controller internal fault
8) locked rotor – fail to rotate
9) low coolant level
10) low oil pressure
11) master switch error
12) NFPA common alarm
13) overcrank
14) overspeed with user adjustable level, range 65-70 Hz on 60 Hz systems and 55-70 Hz on 50 Hz systems
15) generator overvoltage with user adjustable level, range 105% to 135%
16) overfrequency with user adjustable level, range 102% to 140%
17) underfrequency with user adjustable level, range 80% to 90%
18) generator undervoltage with user adjustable level, range 70% to 95%
19) coolant temperature signal loss
20) oil pressure gauge signal loss

b. Will cause a warning but leave the generator running:
1) battery charger failure
2) customer programmed digital auxiliary input on (any of the 21 inputs available)
3) customer programmed analog auxiliary input on
4) power system supplying load
5) ground fault detected – detection by others
6) high battery voltage – level must be user adjustable
7) range 29-33 volts for 24-volt systems
8) high coolant temperature
9) load shed
10) loss of AC sensing
11) underfrequency
12) low battery voltage – level must be user adjustable, range 20-25 volts for 24-volt systems.
13) low coolant temperature
14) low fuel level or pressure
15) low oil pressure
16) NFPA common alarms
17) overcurrent
18) speed sensor fault
19) weak battery

20) alternator protection activated

7. Inputs and Outputs:
   a. Inputs
      1) There shall be 21 dry contact inputs that can be user configured to shutdown the generator or provide a warning.
      2) There shall be 7 user programmable analog inputs for monitoring and control.
      3) Each analog input can accept 0-5 volt analog signals.
      4) Resolution must be 1 part in 10,000.
      5) Each input can be programmed to provide up to 4 trip values – 2 warnings and 2 shutdowns.
      6) It must be possible to view the analog value on the display.
      7) It shall be possible to define each user configured input using words or phases that will be viewable on the digital display.
      8) Additional standard inputs required:
         a) Input for an external ground fault detector. Digital display must show "ground fault" upon detection of a ground fault.
         b) Reset of system faults.
         c) Remote two wire start.
         d) Remote emergency stop
      9) Idle mode enable
   b. Outputs:
      1) All NFPA 10 Level 1 outputs shall be available.
      2) There shall be thirty outputs available for interfacing to other equipment:
         a) Any of these outputs shall be able to be user configured from a list of over 25 functions and faults.
         b) These outputs shall drive optional dry contacts.
         c) At a minimum, configure the following dry contact outputs:
            1) Generator Common Alarm
            2) Generator Running
            3) Fuel Low
      3) A programmable user defined common fault output with over 40 selections shall be available.
8. System Programming:
   a. It must be possible to disable programming so the system can only be monitored.
   b. It shall be possible to program the control with the controller keypad or using a personal computer.
   c. Programming access is to be enabled only at the controller and shall be password protected.
   d. The following shall be programmable from the controller keypad:
      1) Time delay settings:
         a) generator run time (0 to 72 hours) – exercise

b) load shed
c) engine start
d) engine cooldown
e) overvoltage and undervoltage delays
f) staring aid
g) crank on and crank pause time
h) idle time
i) lead/lag

2) Trip point settings:
a) high battery voltage
b) low battery voltage
c) overspeed
d) underfrequency
e) overfrequency
f) overvoltage
g) undervoltage
h) load shed

9. Communications:
   a. The controller shall communicate to the ECM for control, monitoring, and diagnostics.
   b. Industry standard Modbus RTU communication shall be available.
   c. A Modbus master will be able to monitor controller data.
   d. A Modbus master will be able to alter parameters.
   e. The Modbus master must be capable of starting and stopping the generator.

E. Automatic Starting System:
   1. The electric starting system for the unit shall include single, 12 volt d-c starting motors.
   2. Provide 12 volt lead acid storage battery set with battery service safety kit and cell covers, for the unit, of the heavy duty diesel starting type. Batteries shall be of sufficient capacity to provide full cranking power for 1-1/2 minutes cranking time without recharging at a battery and engine temperature of 32 degrees Fahrenheit (assume SAE 30 oil for calculation purposes). Supply battery racks, warming pads and all necessary cables. The battery warming pads shall be wired to a common cord with the jacket water heater for connection to by the Contractor.
   3. The battery charger to be 6-Ampere automatic float and equalize battery charger with +/-1% constant voltage regulation from no load to full load over 1+/-10% AC input line variation, current limited during engine cranking and short circuit conditions, temperature compensated for ambient temperatures from –40°C to +60°C, 5% accurate voltmeter and ammeter, fused, reverse polarity and transient protected.

2.03 WEATHERPROOF, WALK-IN, SOUND ATTENUATED ENCLOSURE

A. General:
   1. The enclosure shall be weatherproof, walk-in style, sound attenuated to reduce radiated noise from installed equipment by 40 dB(A) at one meter.
   2. The enclosure shall consist of a roof, two sidewalls, and two end walls, incorporating prepainted aluminum stressed-skin semi-monocoque construction and application-specific acoustic insulation, lining and air handling equipment designed to provide the specified level of sound attenuation. Rated wind load shall be 125 mph.

B. Roof:
   1. The roof shall incorporate a positive camber and be comprised of a mill-finish 6063-T6 extruded aluminum perimeter channel or "roof rail" with 16 gauge (minimum) roll-formed galvanized crossmembers or "roof bows" mechanically fastened to the roof rails.
   2. The roof skin shall be a nominal 0.040-inch thick 3003-H16 or 3105-H14 mill-finish aluminum sheet and fastened to the roof bows and roof rails. The top skin shall be rolled over the perimeter of the roof rails so as to provide additional weather protection. A weatherproof mastic/sealant shall be used at the perimeter, as well as any joints required in the roof skin. The top skin shall be comprised of separate sheets of roof skin joined with lock-seam construction. This joint(s) shall include a high performance mastic tape or sealant for both joint structural integrity and weather protection.

C. Walls:
   1. The walls shall be manufactured utilizing mill-prepainted 0.040 inch thick (nominal) 3004-H36 aluminum panels hard-riveted to fabricated aluminized steel "Z" section wall posts located on 24 inch (maximum) centers. The enclosure walls shall incorporate an extruded structural "panel-cap" of mill finish extruded 6063-T6 aluminum.
   2. The panel-cap will interlock into the adjoining roofrail for a weatherproof structural connection between the roof and sidewalls.

D. Corner Posts:
   1. Corner posts shall be pairs of mating/interlocking mill finish 6063-T6 aluminum extrusions with one-half of each pair attached to the end of the wall. The halves will interlock upon assembly forming a structural, weatherproof corner.

E. Removable End Wall:
   1. End walls shall be of a removable type retained with 0.250-inch stainless steel thread-forming hardware to facilitate equipment installation and maintenance. Available on all enclosure end walls without adjacent intake/exhaust plenums.

F. Insulation and Lining:
   1. Thermo-acoustic insulation or a thermo-acoustic composite material shall be installed on the interior roof and wall panels of a weight and thickness consistent with the specified level of noise reduction. The insulation shall be covered with mill finish 0.032-inch thick (nominal) perforated aluminum interior lining for the purpose of protecting the insulating medium as well as allowing noise to permeate the absorptive material.

G. Perimeter Tie-Down Frame:
   1. Perimeter tie-down frame fabricated of 0.1875-inch (minimum) steel with inward-facing foot pads suitable for bolting to a concrete pad, etc.

H. Doors:
   1. Commercial doors shall be of 18-gauge galvanized steel construction painted to match the enclosure exterior and incorporated into 16-gauge painted galvanized steel frames that are structurally integrated into the enclosure wall. The door(s) shall include heavy-duty continuous aluminum gear hinges and a passage latch, which includes commercial key-sets. The passage latch shall incorporate a handicapped-access style lever-type operator for ease of egress in the event of emergency. The latch hardware shall allow escape from within when locked externally. Doors shall include a positive restraint to prevent the door from opening more than 100 degrees in normal operation. Door holdback hardware shall be provided to secure the door to the enclosure wall when the door is opened approximately 180 degrees during installation and maintenance evaluations. Wall adjacent to door includes aluminum protector place for impact protection from the protruding door handle. All door openings include an overhead rain gutter for channeling rainwater away from the enclosure. Include panic bar exit hardware.

I. Lift Points:
   1. Lift rings shall be provided at the base or tank perimeter for the purpose of lifting the complete enclosure with installed genset and empty fuel tank into place. The lift rings shall be fabricated of 1.25-inch thick (nominal) steel place and welded into the base of rupture basin (if applicable) perimeter at 4 locations. If a fuel tank/rupture basin is used, the lift rings shall be labeled “for lifting only with tank empty”.

J. Air Handling Devices:
   1. Inlet and exhaust air handling equipment shall be designed so as to maintain a combined total maximum static pressure drop of 0.5 inches of water gauge through the enclosure, including all air handling devices.
   2. Inlet air will be through a fixed or operable louver, weather hood, acoustigrid, or a combination thereof, as specified, and shall provide the necessary level of attenuation. Inlet air handling devices shall be sized and designed so as to minimize the entrance of debris, rain and snow.

Inlet openings shall be screened to prevent the entrance of rodents, miscellaneous debris, etc.

3. Dampers shall not be used as inlet air handling devices, except where incorporated within the primary air handling device for the purpose of providing a controlled temperature environment within the enclosure. Gravity dampers shall not be used in an inlet application.
4. Air discharged from the enclosure shall be through gravity or motor operated discharge dampers, weather hoods, acoustigrids, plenums, or combination thereof, and shall provide the necessary level of attenuation. Discharge openings in hoods or acoustigrids shall be protected with screen.

5. Third party test data shall be available to support the devices used within the air handling system to insure that the maximum allowable 0.5 inches watergauge static pressure drop has not been exceeded.

K. Electrical Package:
   1. The enclosure shall be furnished with interior fluorescent lighting, electric heater, and convenience receptacle. Power feed to the enclosure shall be 120/208V, 3-phase, 4-wire. The enclosure shall include a 120/208V, 3-phase, 4-wire, 100A minimum distribution panel with main circuit breaker shall be furnished to serve generator jacket water heater and batter charger, in addition to lighting, receptacles, and HVAC equipment. Enclosure shall have exterior lights with photocells on the double door side of the enclosure only and switches for the interior lights next to the double door.
   2. All interior wiring methods shall include rigid metal conduit, THWN conductors, and shall be installed in accordance with applicable NEC requirements.

2.05 FUEL STORAGE SYSTEM

A. Sub Base Fuel Supply Tank
   1. The sub base fuel supply tank shall be Underwriters laboratories Listed, UL142 with a fuel capacity of 7000 gallons. The sub base tank shall be the mounting foundation for the generator. It will be the responsibility of the installing Contractor to obtain installation permits from the authority having jurisdiction as well as conveying to the system supplier and the specifying party any special requirements not identified within this written specification.
   2. The sub base tank shall be a secondary containment double wall design. Both the primary and secondary tanks must be pressure tested for leaks. Closed top diked designs with open or covered secondary containment area are not acceptable. The design of the tank and enclosure shall be designed to contain fuel during filling in accordance with International Fire Code requirements.

3. Primary tank construction is to be 10-gauge steel, rectangular with fully welded corners and structural internal baffles on 30" centers. The primary tank shall be subject to an air tight production pressure test at a minimum of 3-psi as per UL142 guidelines. The primary tank is fully enclosed within the secondary containment tank with 1" annular space on all sides, top and bottom. The secondary containment tank is to be fully welded around the primary tank and subject to the same production pressure test as the primary tank. The entire bottom of the secondary containment tank shall have a one half-inch air space to the concrete foundation mounting pad surface when installed.
4. If the tank's capacity requires the sub base footprint to be larger than the generator base, the sub base tank shall have a tube steel structure spanning the width of the sub base tank for support of the generator and installed equipment. This structure will be attached only to the sub base outer rails for weight transfer to the foundation pad. All exposed sub base beyond the generator footprint shall be covered with aluminum diamond tread floor plate. The sub base outer rails shall have provisions for overhead lifting with a crane rated for the complete system's dry weight. The system manufacturer is to include a lifting diagram detailing lift point dimensions and weights.
5. All tank fittings shall be threaded npt with all required venting devices installed and steel plugs in all spare ports. Tank fittings are to include:
    a. Supply and return engine connections with bottom siphon tubes sized per the engine manufacturer's recommendations. Provide fuel/water separator on supply piping to engine.
    b. Low level dry contact float switch set to show low level condition at 1/3 of the tank's capacity.
    c. Tank fill with padlockable fill cap.
    d. Primary tank normal vent with a minimum 5" riser pipe.
    e. Primary tank emergency vent sized per NFPA 30 using the tanks wetted surface area.
    f. Secondary containment tank emergency vent.
    g. 2" spare port with plug.
    h. Dry contact leak detection float switch located in the lowest point in the secondary containment annular space.
    i. Direct reading mechanical level gauge located adjacent the fill port.
    j. Ports required to accommodate specified leak/level detection equipment.
        1). The sub base tank underside is to be painted with an alkaline resistant undercoating material. All exterior coating shall be high gloss black, two-part polyurethane topcoat with epoxy primer.
        2) It will be the responsibility of the installing contractor to supply all fuel needed for system testing and filling the tank when testing is complete.

3) A solenoid operated fuel shutoff valve shall be provided on the fuel connection between the fuel tank and the generator, in compliance with NFPA 30.
4) All piping, fittings, installation, etc., shall conform to the International Fire Code, and NFPA 30.

PART 3 - EXECUTION

3.01 GENERATOR SET INSTALLATION / APPLICATION / ERECTION

A. The design and construction of the electric generator sets shall be such that they are neat and clean in appearance, and that normal adjustments and maintenance can be effected without use of special tools. See Drawings for generator installation details.

B. An adequate supply of the proper lubricant shall be provided to perform one oil change. In addition, spare elements shall be provided for fuel, oil, and air filters, for one complete change. The engine shall be filled with all necessary liquids required for operation. The fuel tank shall be full of fuel at project completion.

C. The Contractor shall furnish and install insulation suitable for use at temperatures up to 1,500 degrees Fahrenheit on the engine generator set exhaust piping and silencer to prevent heat buildup in the room, provide noise reduction, and optimize operator safety. The insulation shall be custom made to fit the actual layout at the job site and the insulating media shall consist of 2 inch molded calcium silicate as manufactured by Celotemp, or equal. The calcium silicate shall be mitered to fit contours and fittings with all voids filled with high temperature insulating cement (asbestos free). Pipe and fitting insulation shall have a finish of 0.016 inch smooth aluminum sheeting held in place by stainless steel bands.

3.02 WEATHERPROOF ENCLOSURE

A. The generator and housing shall be furnished as a complete integrated package. Only fuel piping connections and electrical power and control wiring terminations shall be required in the field by the Contractor.

B. All necessary exhaust piping and duct connections shall be provided between the generator and housing. Flexible connections shall be made at exhaust and radiator. Provide rain cap on end of exhaust pipe.

3.03 PAINTING

A. Equipment:
1. The generator, diesel engine, and radiator shall be painted the engine manufacture’s standard color. The color of the weatherproof housing shall

be selected by the Owner during Shop Drawing review.

+ + END OF SECTION + +

SECTION 16270

MEDIUM VOLTAGE DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 Scope

A. The ABB Inc. Vacuum Pressure Impregnated (VPI) transformer design is the basis for this specification.

B. This Specification provides the technical requirements for the design, manufacture and test of secondary unit substation transformers. The service conditions shall be as specified in Usual Service Conditions section of C57.12.01.

1.2 Codes and Standards

A. The ventilated dry-type transformers and protection devices in this specification are designed and manufactured according to latest revision of the following standards (unless otherwise noted).
   1. IEEE C57.12.01, General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings
   2. ANSI C57.12.51, Requirements for Ventilated Dry-Type Power Transformers, 501 KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160Volts
   3. ANSI C57.12.55, Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard
   4. ANSI/IEEE C57.98, Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)
   5. ANSI/NFPA 70, National Electrical Code
   6. IEEE C57.12.91, Test Code for Dry-Type Distribution and Power Transformers
   7. IEEE C57.94, Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
   8. IEEE C57.96, Guide for Loading Dry-Type Distribution and Power Transformers
   9. NEMA ST 20, Dry Type Transformers for General Applications
   10. American Society of Testing and Materials (ASTM)
   11. National Electrical Code (NEC)

B. It shall be the Contractor’s responsibility to be, or to become, knowledgeable of the requirements of these Codes and Standards. Any required changes or

alterations to the equipment to meet the Codes and Standards requirements shall be at the expense of the Seller.

C. Equipment proposed by the Contractor that cannot fully meet the requirements of this specification shall have all exceptions clearly stated in the proposal. No exception shall be allowed, unless approved by the Engineer in writing.

1.3 Quality Assurance

A. The manufacturer shall a well-documented quality assurance program, which includes procedures for all activities in order entry, design, material procurement, manufacturing processes, testing, shipping and post shipment.

B. The manufacturer shall have specialized in the design, manufacture and assembly of dry-type distribution transformers for a minimum of 25 years.

C. The transformers shall be manufactured by a company, which is certified to ISO, 9001:1994, EN ISO 9001:1994; BS EN ISO 9001:1994; ANSI/ASQC Q9001: 1994 for design and manufacture of Power, Distribution and Specialty Dry Type Transformers. A certificate of Compliance to this requirement shall be provided with the Shop Drawing Submittal.

D. The test floor shall have a documented calibration program. All equipment shall receive regular calibrations. Calibration standards shall be traceable to National Bureau of Standards. Records of all equipment calibration shall be made available upon request.

E. Measured values of electric power, voltage, current, resistance, and temperatures are used in the calculations of reported data. To ensure sufficient accuracy in the measured and calculated date the test system accuracy requirements listed in ANSI C57.12.01 Table 3 shall be met as a minimum.

1.4 SUBMITTALS

A Manufacturer shall provide copies of following documents to owner for review and evaluation.

1. Outline, nameplate and connection diagram drawings.
2. Installation maintenance and operating instructions
3. A certified test report containing minimum information per IEEE C57.12.91
4. Spare parts list

PART 2 – PRODUCTS

2.1 Transformer Technical Requirements

A. Definitions

1. System Description
   a. The transformer shall be of dry type vacuum pressure impregnated construction, the preferred open-wound dry type technology, and shall be mounted in a suitably ventilated indoor enclosure.
   b. Primary terminations shall be cable connected in air-filled terminal chamber.
   c. Secondary terminations shall be busway or cable connected in air-filled terminal chambers.
2. Core Characteristics
   a. The transformer core shall be constructed of high grade non-aging silicon steel laminations with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. A step-lap mitered core joint shall be used to minimize losses, exciting currents and sound levels. The core laminations shall be clamped together with heavy steel members.
3. Temperature Rise
   a. The average temperature rise of the transformer windings shall be rated at 115°C and shall be built utilizing Class 220°C insulations, regardless of the temperature rise specified. The transformer shall not exceed the specified temperature rise when the unit is operated continuously at full nameplate rating. The transformer shall be capable of carrying 100% of the nameplate rating in a 30°C average, not to exceed 40°C maximum ambient in any 24 hour period.
4. Coil Characteristics
   a. The high voltage and low voltage windings shall be constructed using copper conductors. The conductors shall be insulated with a 220°C insulation. Transformer windings, insulation class 1.2 kV (600v) and below, shall be wound using foil or sheet conductors. A sheet wound coil shall allow for free current distribution within the axial width of the conductor/coil to essentially eliminate axail forces under short circuit. Transformer windings, insulation class 2.5 kV (2400v) and above, shall be wound using wire conductors. The high voltage winding shall be wound over the low voltage winding with sufficient mechanical bracing to prevent movement during fault conditions and sufficient solid Class 220°C insulation to isolate the high voltage winding dielectric potential from the low voltage windings.
   b. Taps Transformer primary winding shall have four 2-1/2 percent full capacity taps, two above and two below rated nominal voltage. No load tap connections shall be made by re-connectable links on the face of the primary winding and shall be located behind removable panels on the front of transformer enclosure. Taps shall be for de-energized operation only.

5. Core and Coil Assembly
    a. After installation of windings on core and stacking of the top yoke core steel, core and coil assembly is to be secured with a rigid frame. Primary and secondary coordination bus assemblies, as required for connection to associated switchgear are to be of bolted construction.
6. Vacuum Pressure Impregnation Process
    a. The coils and all clamping structure and buswork shall be assembled on the core, and then dried at atmospheric pressure in an oven through which hot air is continuously circulated. The totally assembled core and coil assembly shall be vacuum pressure impregnated in polyester varnish. The total VPI process shall apply a one (1) cycle polyester protective shield of varnish to the coils and a protective shield to the bus, core and support structure. The varnish shall be cured on the core and coil assembly following an established temperature vs. time baking cycle in a hot air circulating oven. The VPI process shall effectively impregnate the entire core and coil assembly that results in a unit which is virtually impermeable to moisture, dust, dirt, salt air and other industrial contaminants.
7. Dielectric Withstand
    a. The impulse rating of the transformer must equal or exceed the basic impulse level specified by ANSI for the applicable voltage class. The basic impulse level shall be inherent to the winding design and is to be obtained without the use of supplemental surge arrestors.
8. Vibration Isolation
    1. The transformer shall have vibration isolation pads installed between core and coil assembly and enclosure base structures to prevent the transmission of structure borne vibration.
9. Enclosure
    a. The enclosure shall be constructed of heavy gauge sheet steel and shall be finished in ANSI 61 paint color applied using an electrostatically deposited dry powder paint system. All ventilating openings shall be in accordance with NEMA and the NEC standards for ventilated enclosures. The base of the enclosure shall be furnished with ground pads located on opposite diagonal corners. The base shall have jacking pads and shall be constructed of heavy steel members to permit skidding or rolling in any direction. The core shall be visibly grounded to the enclosure frame by means of a flexible grounding strap.
10. Nameplate
    a. Transformer shall be furnished with a non-corrosive diagrammatic nameplate per ANSI C57.12.01, permanently attached with non-corrosive hardware. The diagrammatic nameplate shall include the name of the manufacturer of the transformer as well as the location where the transformer was manufactured and tested. In addition, the transformer manufacturer and location of manufacture is to be supplied at the time of quotation.

2.2 ACCESSORIES

A. Standard transformer accessories shall include:
   1. Diagrammatic instruction nameplate
   2. Provisions for lifting and jacking
   3. Removable case panel for access to HV taps
   4. Stainless steel ground pads
   5. Line voltage adjustment taps, 2 - FCAN and 2 - FCBN, All at 2 ½%

2.3 TRANSFORMER DATA

KVA Rating: 1500

Frequency: 60 HZ

Impedance: 5.75%

Winding Temperature Rise: 115 °C

Primary Voltage: (kV) 2.4

Primary Taps: Standard (± 2-2 ½)

Primary BIL*: (kV) 45

Primary Connection: Delta

Primary Termination: Air Terminal Chamber

ANSI Segment: 2

Secondary Voltage: 480

Secondary BIL*: (kV) 30

Secondary Connection: Wye

Secondary Termination: Air Terminal Chamber

ANSI Segment: 4

Application Location: Indoor NEMA 1

Forced Air Rating: AA

Sound Level: Standard

PART 3 – EXECUTION

3.1 TEST

A. After completion, each transformer shall undergo the following routine production tests per ANSI C57.12.01 and ANSI C57.12.91. Testing shall be accomplished using calibrated test equipment, which have recorded accuracy traceable to National Institute of Standards Technologies (NIST). Certification of Calibration shall be provided with test reports if requested.
   1. Megger
   2. Ratio
   3. Resistance
   4. Phase relation
   5. Load Loss, Impedance and Regulation
   6. No Load Loss and Excitation Current
   7. 100% QC Impulse Test
   8. Applied Potential Test
   9. Induced Potential Test

B. In addition to routine testing a 100% QC Impulse test shall be performed on each transformer furnished.

C. A temperature rise test shall be performed for the transformer.
   1. The temperature rise of the windings at rated KVA loading shall not exceed maximum rise specified during operation at 30 degrees C average ambient, which does not exceed 40 degrees C in a 24 hour period.

D. A sound level test shall be performed for the transformer.
   1. Sound level shall not exceed the maximum specified by ANSI C57.12.01 for applicable KVA size of dry-type transformer.
   2. The core and coil design and construction techniques shall be verified by a full short circuit test on similar or larger units in accordance with applicable ANSI standards.

3.2 INSTALLATION

A. Transformers shall be furnished and installed in accordance with NEC requirements and manufacturer's instructions.

B. Anchor equipment to foundation.

+ + END OF SECTION + +

SECTION 16271

LIQUID-FILLED SUBSTATION TRANSFORMERS (ALTERNATIVE 2)

PART 1 - GENERAL

1.0 SCOPE

A. The ABB Substation transformer design is the basis for specification.

B. This Specification provides the technical requirements for the design, manufacture and test of substation transformers.

C. The service conditions shall be as specified in Usual Service Conditions section of C57.12.00, unless otherwise modified herein.

1.2 CODES AND STANDARDS

A. All codes and standards referenced in this specification shall be those in effect at the time of Purchase Order award. Deviations from this specification and referenced codes and standards shall be obtained in writing from Buyer.
   1. ANSI/IEEE C57.12.00, Distribution, Power, and Regulating Transformers, General Requirements for Liquid-Immersed ……
   2. ANSI C57.12.10, American National Standard for Transformers 230 kV and Below ……..
   3. ANSI/IEEE C57.12.90, Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
   4. ANSI/IEEE C57.98, Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)

B. It shall be the Contractor's responsibility to be, or to become, knowledgeable of the requirements of these Codes and Standards. Any required changes or alterations to the equipment to meet the Codes and Standards requirements shall be at the expense of the Contractor.

C. Equipment proposed by the Contractor that cannot fully meet the requirements of this Specification shall have all exceptions clearly stated in the proposal. No exception shall be allowed, unless approved by the Engineer in writing.

1.3 QUALITY ASSURANCE

A. The manufacturer shall have specialized in the design, manufacture and assembly of liquid filled LV substation transformers for a minimum of 25 years. The

transformer manufacturer and location of manufacture and test are to be supplied at the time of quotation.

B. The manufacturer shall a well documented quality assurance program, which includes procedures for all activities in order entry, design, material procurement, manufacturing processes, testing, shipping and post shipment product follow.

C. The test facility used to perform loss tests in accordance with ANSI C57.12.90 must be certified by an approved 3rd party to meet NBS 1204 standards for accuracy. Calibration of the equipment used for these loss measurements must be traceable to NIST or an approved equal 3rd party laboratory. Records of all equipment calibration shall be made available to the Engineer upon request.

1.4 SUBMITTALS

A. Drawing Requirements
   1. Submittal drawings shall be completely dimensioned and, as a minimum, show the following:
      a. Plan, and all elevations, including clearance for bushing and core and coil removal.
      b. High voltage and low voltage bushing details.
      c. Location and identification of all accessories.
      d. Size and location of all conduit entrances for connections.
      e. Anchoring details.
      f. Ground pad locations.
      g. Weight of core and coil, transformer tank and fittings, weight and gallons of fluid, and total shipping weight.

B. Wiring diagrams
   1. Detailed connection (wiring) diagrams shall show the following:
      a. Wiring of all devices with switches and relays, or electrical connections, including current transformers.
      b. Identification of all terminal blocks and all connections to be made by Buyer.

C. Nameplate drawing
   1. A nameplate drawing showing required ANSI information shall be provided.

D. Installation, Operating, and Maintenance Instructions
   1. The manufacturer shall provide an instruction, operating and maintenance manual covering all equipment furnished in accordance with Division 1.

PART 2 - PRODUCTS

2.1 TRANSFORMER TECHNICAL REQUIREMENTS

A. Winding Characteristics
   1. All windings and internal connections shall be copper.
   2. All windings shall be circular.
   3. The windings shall be tightly wound utilizing tension devices to place the conductor into the coils.
   4. The transformer windings shall be designed and constructed to be completely self protected by its ability to withstand the external short-circuits, as defined by ANSI C57. 12.00 and tested in accordance with C57.12.90.
   5. The core and coil assembly must be processed using an inert liquid process commonly known as Vapor Phase or Condensation Heating.
   6. The transformer design shall be capable of operating above rated voltage or below rated frequency in accordance with ANSI C57.12.00.

B. Sound Level
   1. The substation transformer and auxiliary cooling equipment shall be designed and constructed to minimize the audible noise generated with the transformer energized at rated voltage and with all auxiliary cooling equipment in operation. The acceptable noise level shall be in accordance with NEMA TR 1. The measurement procedure shall be as specified in ANSI C57.12.90.

C. Bushings
   1. High voltage and low voltage bushings shall be furnished with the ratings indicated herein.

D. Core
   1. The core shall be constructed of high-grade, grain oriented, silicon steel laminations, with high magnetic permeability. Magnetic flux density is to be kept well below the saturation point. The core construction shall include step-lap mitered joints to keep core losses, excitation current and noise level to a minimum.

E. De-Energized Tap Changer
   1. A manually operated de-energized tap changer shall be provided for changing the off circuit taps.
   2. Full capacity taps shall be located in the high voltage windings and shall be in accordance with the Transformer Data Sheet.
   3. The tap changer shall be capable of carrying the full transformer short-circuit current without damage or contact separation.
   4. The tap changer shall be gang operated from a single operating point and shall have an easily visible position indicator.
   5. The tap changer operating mechanism shall include provisions for pad locking in each tap position.

F. Arresters

1. (Alternative No. 2A) The HV side requirements are: 69 kV station class arresters. The arrester mounting location shall be in close proximity to the HV bushings.
2. (Alternative No. 2B) The HV side requirements are: 15 kV station class arresters. The arrester mounting location shall be in close proximity to the HV bushings.
3. The LV side requirements are: 5 kV distribution class arresters. The arrester mounting location shall be in close proximity to the LV bushings.

G. Insulating Fluid And Preservation System

1. The fluid preservation system shall be a sealed tank type.
2. The insulating fluid shall be minimum 3% inhibited mineral oil.
3. The transformer insulating fluid shall be certified to contain no detectable PCB's at the time of shipment and the tank shall be so labeled. Certification shall also be provided that the transformer and components have not been contaminated with PCB's prior to shipment.
4. The transformer insulating fluid shall meet or exceed the requirements of the appropriate ANSI and ASTM fluid Standards. The transformer fluid shall be tested for dielectric breakdown and moisture content just prior to the time of shipment.

H. Tank Design

1. The transformer tank, cooling equipment and compartments subject to operating pressures shall be designed for full vacuum, without permanent deformation. The maximum design withstand pressure shall be indicated on the nameplate.
2. Tank design shall include sufficient expansion volume to allow operation under specified load conditions.
3. The main cover shall be of welded onto the tank.
4. One or more bolted-on handholes shall be provided in the tank cover for access to bushing connections and current transformers, when required. The opening shall be of sufficient size to allow removal of any CTs.
5. The transformer base shall be suitable for rolling or skidding in the direction of either tank base centerline.
6. Lifting lugs shall be provided at each corner of the tank. The lifting lugs shall be designed to provide a minimum safety factor of 5.
7. Jacking pads or bosses shall be provided.
8. Pulling provisions, for towing the transformer parallel to either centerline, shall be provided.

I. Gaskets

1. The gaskets shall be compatible for the insulating fluid in the transformer tank.

2. All gaskets shall have a circular cross-section and be made of oil and heat resistant synthetic nitrile rubber with a durometer hardness of 65 or more.
3. All gaskets shall be captured in a machined groove.
4. Gaskets for exposure to enclosed buss duct continuous shall be Viton material.
5. Metal surfaces to which gaskets are applied shall be smooth, and shall have sufficient rigidity to assure proper compression of the gaskets.

J. Cooling System
1. Cooling tubes or radiators shall be rigidly supported to the tank wall, either through pipes or brackets.

K. Grounding Provisions
1. All non-energized metallic components of the transformer shall be grounded.
2. Tank grounding provisions shall consist of two ground pads, welded to the base or to the tank wall near the base on diagonal corners.
3. The ground pads shall be copper-faced or stainless steel with two holes spaced horizontally at 1.75-inch centers and tapped for 0.5 inch 13-UNC tread.

L. The control cabinet shall be NEMA Type 4. The cabinet door shall have provisions for padlocking.

M. Wiring
1. All devices mounted on the transformer, including current transformer LV circuits, shall be wired to the control cabinet.
2. All control wiring shall be a minimum of #14 AWG SIS and #10 AWG for current transformers. Wiring between gauges and the control box can be #14 AWG SO cable.
3. Wiring shall be terminated with a ring-type insulated compression lug.
4. Current transformer terminal blocks shall be the shorting type.
5. Each wire shall be identified with a wire marker.

N. Nameplates
1. Transformer shall be furnished with a non-corrosive diagrammatic nameplate, permanently attached with non-corrosive hardware. The diagrammatic nameplate shall include the name of the manufacturer of the equipment as well as the location where the transformer was manufactured and tested.
2. The nameplate shall contain all connection and rating information in accordance with ANSI C57.12.00 nameplate type C, plus the approximate weight of parts to be lifted for un-tanking, type and quantity of oil, and the date of manufacture.

3. A non-corrosive nameplate located next to the operating handle of the de-energized tap changer shall be provided which states the following: 'Danger - Do not operate tap changer when the transformer is energized."

O. Exterior Finish
   1. The transformer exterior painting system shall be the manufactures standard. However, as a minimum, the transformer shall be thoroughly cleaned and phosphortized, painted with at least one corrosion inhibiting primer and one finish coat to provide a minimum total dry-film thickness of not less than 5 mils.
   2. All internal steel surfaces should be painted white except metals used in the electrical or magnetic circuit.
   3. The finish shall be ANSI 70.

2.2 ACCESSORIES

A. The transformer shall be equipped with a complete set of accessories, as per ANSI C57.12.10.

2.3 TRANSFORMER DATA (ALTERNATIVE 2A)

3 KVA Rating: 7,500

Frequency: 60 HZ

Impedance: ANSI C57.12.10 Standard

Winding Temperature Rise: 65 °C

HV Voltage: 69 kV

HV Taps: Standard (2 ANBN +2 ½ %)

HV BIL: 150 kV

HV Connection: Delta

HV Termination: Cover Bushing

HV Location: Standard

LV Voltage: 2.4 kV

LV BIL: 45 kV

LV Connection: Delta

LV Termination: Air Terminal Chamber

LV Location: ANSI Segment 4

Cooling: Outside Air

Sound Level: Standard

2.4 TRANSFORMER DATA (ALTERNATIVE 2B)

3 KVA Rating: 7,500

Frequency: 60 HZ

Impedance: ANSI C57.12.10 Standard

Winding Temperature Rise: 65 °C

HV Voltage: 12.47 kV

HV Taps: Standard (2 ANBN +2 ½ %)

HV BIL: 150 kV

HV Connection: Delta

HV Termination: Air Terminal Chamber

HV Location: ANSI Segment 4

LV Voltage: 2.4 kV

LV BIL: 45 kV

LV Connection: Delta

LV Termination: Air Terminal Chamber

LV Location: ANSI Segment 4

Cooling: Outside Air

Sound Level: Standard

PART 3 – EXECUTION

3.1 TEST

A. Testing
   1. Each transformer shall receive all standard routine tests as required by ANSI C57.12.00 and performed as specified by ANSI C57.12.90.
   2. A certified test report shall be submitted and shall contain the test data for each transformer serial number manufactured. The certified test report shall as a minimum contain the data as specified in ANSI C57.12.90.
   3. Short Circuit withstand capability shall be verified by full short circuit tests on similar or larger units in accordance with the latest revision of ANSI C57.12.00 and ANSI C57.12.90. The maximum allowable variation in impedance measured on a per-phase basis after the test series shall not differ from that measured before the test series by more than 2% for category II and III equipment for circular or noncircular coils. Certified test reports from applicable short circuit tests shall be submitted to the purchaser, upon request, prior to shipment of the transformers.
   4. All symbols and wiring identification systems shall be in accordance with the applicable ANSI standard.

3.2 INSTALLATION

A. Transformers shall be furnished and installed in accordance with NEC, NESC, power company requirements, and manufacturer's instructions.

B. Anchor equipment to foundation.

+ + END OF SECTION + +

SECTION 16280

SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Instrumentation Surge Protection Devices
   1. Surge Protection Devices are intended for use on all instrument control loops for power and signal protection on transmitters/receivers, etc., and shall be furnished and installed as specified in Division 13.

B. Secondary Power Arrestors (480, 240, or 240/120 Volts a-c)
   1. Secondary power arrestors shall be furnished and installed on all control equipment supplied as outlined on the Contract Drawings.

C. Surge Protection Devices (480, 240, or 240/120 Voltage)
   1. Surge Protection Devices shall be furnished and installed in all Power Distribution Panels and on all equipment supplied having solid state components as the central control/monitoring device. These shall included, but not be limited to, computer systems, level control systems, and/or variable speed equipment. They shall be shown on the Drawings where required.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Secondary Power Arrestors
   1. "Dale," "General Electric," or equal.

B. Hybrid Surge Protection Devices
   1. "Atlantic Scientific Corporation," "LEA Dynatech," "Current Technology," "Advanced Protection Technologies," or equal.

2.2 EQUIPMENT

A. Secondary Power Arrestors
   1. The arrestor shall be hermetically sealed with pre-ionized spark gap. The unit shall be capable of repeated overvoltages without significant change in breakdown level or insulation resistance. The arrestor shall be capable of mounting in any position and shall be capable of mounting through a box knockout with standard locknuts, and shall be weatherproof.
   2. Capacitance shall be less than 50 picofarads, and insulation resistance shall be at least 100 megohms. Maximum arc-over with 10 KV/micro second

rise time pulse applied shall be 1,500 volts. The arrestor shall be capable of withstanding repeated application of 10 kiloampere current surges and extinguish power-follow current in 2 cycle or less. Maximum voltage between terminals shall be 2,500 volts when conducting 10 kiloampere current surges.

3. Operating temperature range shall be -40 degrees Celsius to +75 degrees Celsius.

B. Surge Protection Devices

1. The nominal operating voltage and configuration shall be as indicated on the contract drawings.
2. The maximum continuous operating voltage (MCOV) of all suppression components utilized in the unit shall not be less than 115% of the facility's nominal operating voltage.
3. SPD shall be UL labeled with 20kA Inominal (I-n) for compliance to UL 96A Lightning Protection Master Label and NFPA 780.
4. The system shall provide a noise filtering system capable of attenuating noise levels produced by electromagnetic interference and radio frequency interference. The system's filtering characteristics shall be expressed in decibels (dB) of attenuation per NEMA LS1 publication. The noise filtering system shall also be UL 1283 listed as an Electromagnetic Interference Filter.
5. The SPD unit, in the configuration required by this project (integral disconnect or no integral disconnect), shall have a minimum interrupt rating of 200kAIC.
6. NEMA LS-1-1992 (R2000) Clamping Voltage Data. The unit's clamping voltages shall be in compliance with test and evaluation procedures outlined in NEMA LS-1-1992 (R2000), paragraphs 2.2.10 and 3.10.
7. The unit shall be UL 1449 3rd Edition Listed. The UL 1449 2nd Edition suppressed voltage ratings (SVR) for the unit including integral disconnect shall be equal to or below the following values:

UL 1449 3rd Edition Suppressed Voltage Ratings (SVR)				
System Voltage	Mode of Protection			
	L-N	L-G	N-G	L-L
120/240	700	700	900	1000
120/208	700	700	500	700
277/480	1000	1200	1200	1800

8. Tested Single Pulse Surge Current Capacity.
   a. The maximum single-pulse surge current capacity per mode shall be verified through testing at an independent third party testing facility and shall be conducted per NEMA LS-1-1992 (R2000), paragraphs 2.2.9 and 3.9. The unit shall be tested in all modes at rated surge currents and all tested modes shall be from the same test sample. This test shall include all components of the system, including disconnects (if applicable), fusing, and monitoring as a completed assembly.

Individual component testing, module testing only, or subsystem testing of the unit for compliance with this section will not be acceptable. Testing that causes damage to the device, fuse operation, or voltage clamping performance degradation by more than 10% is not acceptable.

9. Minimum Repetitive Surge Current Capacity.
    a. Per IEEE C62.41-1991 and C62.45-2002, the product shall be repetitive surge current capacity tested in every mode utilizing the following:
        1) 1.2 x 50 sec, 20 KV open circuit voltage, 8 x 20 sec, 10 kA short circuit current Category C3 combo-wave at one minute intervals without suffering either performance degradation or more than +10% deviation of clamping voltage at the specified surge current.
        2) The device shall be capable of surviving a minimum of 11,000 impulses without failure or performance degradation.
10. Service Entrance Suppressors
    a. Equipment shall Equipment shall be a multi-stage parallel protector rated for 480Y/277. See online diagram and panelboard schedule to confirm voltages. The equipment's minimum surge current capacity shall be 200kA per mode (L-N, L-G, L-L and N-G).
    b. The system protection modules shall contain a technology that utilizes a symmetrical array of balanced metal oxide varistors (MOV). Each MOV will be individually coordinated to pass UL 1449.
    c. All primary transient paths shall utilize copper wire, aluminum bus bar and lugs of equivalent capacity to provide equal impedance interconnection between phases. No plug-in module or components shall be used in surge carrying paths.
    d. Each protection module shall have a visual indicator that signifies that the protection circuitry is on line. The unit shall not be taken off line to verify integrity of system. Redundant status indicators shall be mounted on the front of the door that monitors the system protection circuitry (or be visible through the enclosure front).
    e. The system shall be modular with field replaceable modules. Modular units shall contain a minimum of one module per phase.
    f. Equipment shall utilize a NEMA 1 enclosure.
11. Panelboard Suppressors & Auxiliary Panel Suppressors
    a. Device shall meet all specification requirements for service entrance suppressors except as follows:
        1) . Equipment shall be a multi-stage parallel protector rated for 480Y/277 or 208Y/120. See online diagram and panelboard schedule to confirm voltages. The equipment's minimum surge current capacity shall be 100kA per mode (L-N, L-G, L-L and N-G).
        2) . The system protection shall contain a technology that utilizes a symmetrical array of balanced metal oxide varistors (MOV).

Each MOV will be individually coordinated to pass UL 1449. The unit shall be non-modular type.

3) . Equipment shall utilize a NEMA 1 enclosure.

12. Accessories
    a. Device Monitoring
        1) . As a minimum, device monitoring shall include: Audible alarm with alarm disable switch, surge counter, and two sets of Form C contacts for remote monitoring.
    b. Integral Disconnect Switch
        1) The unit shall include an integral safety interlocked disconnect located in the unit enclosure with an externally mounted manual operator. If fuses are included with this switch, the fusing shall not effectively lower the rating of the SPD unit.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Where the SPD unit is not specified with an integral safety/disconnect switch an appropriately sized disconnect switch or thermal magnetic breaker shall be installed before and in-line with the SPD. It shall be capable of electrically isolating the SPD from the electrical service for repair without interrupting service to the building. If a safety/disconnect switch is utilized the switch shall be rated for 600VAC. If fuses are included with this switch, the fusing shall not effectively lower the rating of the SPD unit and shall have a minimum interrupt rating of 200kAIC. Connection means utilizing breakers shall be sized at 60A/3P and 30A/3P respectively for service entrance/switchboard/switchgear and branch panelboard units unless otherwise recommended by manufacturer.

B. The specified SPD system shall be installed with #6 AWG minimum copper conductors tapped from the electrical power distribution system. The conductors are to be as short and straight as practically possible and shall not exceed 5 electrical feet from the power conductor(s) it is protecting for service entrance/switchboard/switchgear units and 1.5 electrical feet for branch panelboard units, and shall avoid any unnecessary or sharp bends. The input conductors are to be twisted together to reduce the SPD system inductance.

C. The SPD shall be installed following the SPD manufacturer's recommended practices and in compliance with these specifications and all applicable codes.

3.2 WARRANTY

A. Manufacturer shall provide a full 5-year limited warranty against failure or workmanship defects when installed in compliance to the manufacturer's written installation instructions, UL listing requirements and the National Electrical Code.

+ + END OF SECTION + +

SECTION 16312

MEDIUM VOLTAGE POWER DISTRIBUTION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The power distribution cabling system shall be installed in accordance with NEC and NESC requirements, and as written herein and as shown on Contract Drawings. For further information on components/installation not addressed in this article, refer to other sections of this Division, and the Contract Drawings.

B. Ends of conduits shall be sealed where they enter buildings at service equipment and empty (spare) conduits shall be capped at both ends. Spare conduits shall extend 5 feet from buildings or structures unless otherwise shown on the Contract Drawings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Conduit
   1. Underground nonmetallic conduit shall be George-Ingraham, Ciba-Geigy, or equal. Other types of conduit for transitions to building interiors, etc., shall be as specified in 16130 - Raceways.

B. Duct Spacers and Terminators
   1. Duct spacers and terminators shall be Formex, or equal.

C. Medium Voltage Insulated Power Cables
   1. Medium voltage insulated power cables shall be Okonite, Anaconda, or equal.

D. Prefabricated Splice Kits and Terminations
   1. Prefabricated stress cones, shield grounding adapters, splice kits, and terminations hall be as manufactured Elastimold, 3M, Cooper, G&W, or equal.

2.2 MATERIALS

A. Conduit
   1. Underground duct lines for medium voltage shall be fiberglass duct or PVC, concrete encased.

B. Duct Spacers and Terminators
   1. Spacers shall be made from high density polyethylene, and shall be double wall construction. They shall consist of interlocking modules, i.e. bases, intermediates and caps. Base pads shall be used to assure specified dimensions between trench floor and bottom of first tier of ducts. The interlocking modules shall include an internal vertical channel on both side edges of the spacers. The interlocking module spacers shall provide independent support for each duct, and 3 inch separation between ducts.
   2. Terminator modules shall be made from high impact, high strength, prime virgin acrylonitrile butadiene styrene (ABS) plastic, Marbon Type G.S., or equal. Terminator module shall interlock and be sealed together using a recommended plastic solvent cement. The openings of the terminator facing the inside of the manhole shall be belled.

C. Medium Voltage Insulated Power Cables
   1. 5 KV cables shall have the following specifications:

Conductor:	Uncoated copper, stranded
Cable Arrangement:	Single conductor
Strand Screen:	Extruded, semi-conducting
Insulation:	5 KV cable 115 mils EPR
Insulation Screen:	Extruded, semi-conducting
Shield:	Uncoated copper tape, helically wrapped, 12.5% overlap
Jacket:	PVC
Temperature Rating:	105EC continuous 140EC emergency 250EC short circuit

D. Prefabricated Splice Kits and Terminations
   1. Molded Rubber Shielded Cable Splice
      a. The shielded cable splices must be capable of normal continuous operation at the rated voltage and current on the cable on which it is to be used (up to 35 KV). The splice must consist of an all-molded rubber splice body with black semi-conductive EPR rubber. All EPR rubber must be cured with a peroxide cure. All splices must be able to be installed without the use of mechanical advantage installation tools. Where required, shield adapters must be capable of quickly extending the cable shielding for outdoor, indoor, and buried applications.
   2. Molded Rubber Cable Termination
      a. The shielded cable termination must be capable of normal continuous operation at the rated voltage and current on the cable it is to be used on (up to 35 KV); and it should meet all the requirements of a Class 1 Termination as given in IEEE Standards. The termination must

consist of a high quality rubber molded stress cone made of track resistant peroxide cured EPR rubber and a one-piece silicone rubber skirted insulator for 15 KV (two-piece silicone skirted insulator for 25 and 35 KV). A mechanical (non-solder) ground strap assembly shall be included as a part of the kit. All materials (except lug) necessary to make three terminations shall be included as part of the basic 5 to 15 KV kit. This should include cable preparation materials. Additional materials may be necessary in order to convert the basic 5 to 15 KV kit into a 25 or 35 KV termination; however, the instructions packed with the kit should include all of the information as to what is needed for 25 and 35 KV.

3. Shield Grounding Adapter
   a. The shield ground adapter must be capable of use at the rated voltage of the cable it is used on, and shall be totally mechanical, requiring no soldering or taping. It shall be watertight. The housing shall be molded conductive rubber. The ground lead shall be copper. Contact with the cable shield shall be by compression of a corrugated internal contact. Compression shall be accomplished by external stainless steel clamp(s).
4. Loadbreak and Deadbreak Elbow Connectors and Accessories
   a. Insulated high voltage cable shall be terminated using deadfront elbows at padmount transformers. 200 Ampere elbows shall be loadbreak and 600 ampere elbows shall be deadbreak. Voltage class shall be 15 KV. The insulating elbows shall be molded of EPDM rubber with integral stress cones. The 200 ampere devices shall accept No. 6 - No. 4/0 conductors and the 600 ampere devices shall accept No. 2/0 - 1000 MCM conductors. Both type connectors shall be watertight and shall include all accessories needed for connection to conductor. Other characteristics:

Impulse Voltage:	95 KV BIL
Withstand Voltage:	34 KV, 60 Hz., 1 Minute
Minimum Corona Extinction Level:	11 KV
Momentary:	10,000 amps RMS Symmetrical

   b. Cable shield grounding adapters shall be furnished and installed as needed. Necessary bushing shall be furnished and installed in switches and transformers for proper mating with the elbow connectors. Feed through bushings shall be used at transformers so that deadfront arresters may be connected to the unused feed through bushing.
   c. The deadfront arrestor shall be gapless, of solid state design using a metal oxide varistor enclosed in a molded elbow similar to the elbow connector housing.

d. Furnish insulated protective caps where needed to maintain the deadfront, watertight arrangement where a bushing is unused.

E. Surge Arrestors

Surge arrestors shall comply with IEC 60099-4, and shall be provided for protection of cabling, switchgear, motor control centers, transformers and other indicated equipment. Arrestors shall be distribution class, rated as shown. Arrestors shall be equipped with mounting brackets suitable for the indicated installations. Arrestors shall be of the metal-oxide varistor type with silicone housing suitable for indoor or outdoor installations.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Duct

1. General

a. The duct system shall consist of single or multiple round-bore conduit for the electrical-distribution system. The number and size of the ducts shall be as indicated on the Contract Drawings. Duct lines shall be laid to a minimum grade of 4 inches per 100 feet. Duct shall be laid so that the top of the duct is 24 inches below finished grade or finished paving. Changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be used at the ends of the run. The long sweep bends may be made up of one or more curved or straight sections and/or combinations thereof. Manufactured bends shall have a minimum radius of 18 inches for use with ducts of less than 3 inches in diameter and a minimum radius of 36 inches for ducts of 3 inches in diameter and larger. Conduits shall terminate in end bells where duct lines enter manholes. Conduit shall be thoroughly cleaned before using or laying. During construction and after the duct line is completed, the ends of the conduit shall be plugged to prevent water washing mud into the conduits or manholes. Particular care shall be taken to keep the conduits clean of concrete, dirt, and any other substance during the course of construction.

b. Where it is necessary to cut a tapered end on a piece of conduit at the site, the cut shall be made with a tool or lathe designed to cut a taper to match the taper of the particular conduit being used. After the duct line has been completed, a standard flexible mandrel not less than 12 inches long, having a diameter approximately 1/4 inch less than the inside diameter of the conduit, shall be pulled through each conduit, after which a brush with stiff bristles shall be pulled through each conduit to make certain that no particles of earth, sand, or gravel have

been left in the line. Pneumatic rodding may be used to draw in the lead wire. Where connection is made to an existing duct that is of different material and shape than the duct line being installed, a suitable coupling of a type recommended by the duct manufacturer shall be used. Conduits shall be stored to avoid warping or deterioration. Plastic conduit shall be stored on a flat surface and protected from the direct rays of the sun. Conduit joints in concrete encasement may be placed side by side horizontally but shall be staggered at least 6 inches vertically.

c. Each single conduit of the duct bank shall be completely encased in concrete. The thickness of the concrete encasement indicated is the minimum thickness, and may be increased to fit the actual shape of the trench. Duct spacers shall be used, placed on 4 feet centers. When the duct bank is assembled, a No. 3 reinforcing rod shall be passed through the internal vertical channels on one side of the spacer bank and driven into the trench floor. At the next spacer location, the No. 3 rod shall be inserted on the opposite side, etc. The reinforcing rods shall be bent inwardly at the top of the spacer bank sufficiently to squeeze the spacer cap so the duct assembly will not float or move in any direction during the concrete pour. Concrete encasement shall not be less than 3 inches on the side, bottom, and top of the conduits.

2. Couplings

a. Joints in conduit shall be made up in accordance with the manufacturer's recommendations for the particular conduit and coupling used. The plastic or fiberglass conduit joints shall be made up by brushing a plastic solvent cement or epoxy (as applicable) on the inside of the coupling and on the outside of the conduit ends. The conduit and fitting shall then be slipped together, until seated, with a slight twist to set the joint tightly, and the conduit then rotated 2 turn to distribute the cement evenly. Excess cement build up on the inside surface of the conduit shall then be removed.

B. Medium Voltage Insulated Power Cable Systems

1. The power cable systems shall consist of ethylene-propylene rubber insulated PVC jacketed conductors. The size and number of conductors shall be as indicated on the Contract Drawings. Conductors shall be stranded. Cables for use on 2,400 and 4,160 volt power systems shall be rated 5,000 volts and cables for use on 12,470 volt power systems shall be rated 15,000 volts. Cables shall be insulated to the 133 percent level. The neutral conductors of grounded neutral systems shall consist of stranded 600 volt polyethylene jacketed cables suitable for direct burial or duct shown on the Contract Drawings. Power cables shall be installed in duct lines as specified this section.

2. It is intended that cables be continuous as much as is practical without unnecessary splices. Cable splices, however, shall be made in manholes or junction boxes if necessary, and shall be installed at no extra cost to the

Owner. Cable splices and terminations shall be made up in accordance with cable manufacturer recommendations, by persons qualified to make such splices/terminations. Qualification shall consist of proof that the person(s) working on splices and terminations has at least 3 years experience with the type cables and connectors encountered on this project.

3. Cable pulling shall be accomplished using industry recognized pulling equipment and techniques, and shall be done in accordance with cable manufacturer's recommendations. All cable shields shall be grounded at both ends.

D. Prefabricated Splice Kits and Terminations

1. Splices and terminations shall be of a type appropriate for the cable type and for the environment encountered, either indoor or outdoor. All kits shall include premolded stress cones and all necessary materials needed for proper installation. The Contractor shall furnish necessary lugs, etc. for mechanical hookup from cables to equipment.
2. All terminations and splices shall be installed in accordance with manufacturer recommendations and shall be complete with all necessary accessories for an operational system. All terminations and splices shall be made prior to cable Hipot testing. All lightning arresters shall be properly grounded. All terminations in outdoor cabinets shall be treated as outdoor and terminated accordingly.

3.2 FIELD QUALITY CONTROL

A. A DC Hipot test shall be conducted on all cables before hookup and after pulling, when the cables are fitted with all terminating and splicing kits. Testing shall be in accordance with IEEE and manufacturer recommendations with test voltage for each cable as advised by the manufacturer. All cable shields shall be grounded during testing and ends of cables under test adequately insulated from grounded equipment and other equipment not under test. Submit a written report of test results to the Engineer on all cables.

B. Prior to Hipot testing, the Contractor shall utilize a high voltage megger to detect gross insulation system failure. The Hipot test on a very low quality insulated cable is destructive, and screening the cables first with the megger may prevent the Contractor replacing an otherwise salvageable cable.

C. Hipot testing shall also be performed on existing cables which have been disturbed during the course of this work.

+ + END OF SECTION + +

SECTION 16315

PRIMARY GROUNDING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Grounding shall conform to applicable requirements in the NEC and NESC and as written elsewhere in these Specifications. Neutral conductors, cable shields, metallic conduits, termination bodies, junction boxes, lightning arrestors, fences (if applicable), and all non-current carrying metallic parts of equipment, shall be grounded. Ground rods shall be copper, or copper-clad steel, 3/4 inch minimum diameter, at least 10 feet long, driven fully into the earth.

B. Grounding electrodes at transformers and switches shall have a ground resistance not to exceed 5 ohms. Ground resistance shall be measured not less than 48 hours after rainfall. A bare copper cable not smaller than No. 4/0 AWG shall be installed not less than 30 inches below grade connecting to the indicated ground rods. Fence and equipment connections shall not be smaller than No. 4 AWG. Fences shall be grounded at every gatepost and cornerpost. Each gate section shall be bonded to the fencepost with a flexible braided copper grounding strap. Transformer neutral connections shall not be smaller than 1/0 AWG. Where rated secondary current exceeds 400 amperes, the size of the neutral ground connection shall be increased to not less than 2 of the area of secondary phase conductors. Where measured ground resistance exceeds 5 ohms, additional rods shall be driven, not less than 10 feet apart, connected with 4/0 cable, until proper resistance is achieved (50 foot total rod length maximum).

C. All concealed or buried grounding system connections or grounding electrode connection shall be of the exothermic weld type.

D. Lightning arrestor grounding conductors shall be separate from other grounding conductors, but shall be bonded to the neutral or to the equipment ground where such ground exists within 50 feet.

E. All grounding electrodes at transformers and lightning arrestors shall be tested for conformance to the 5 ohm value and the procedure shall be the same as described in Section 16060 on secondary grounding.

PART 2 – PRODUCTS Not Applicable.

PART 3 – EXECUTION Not Applicable.

+ + END OF SECTION + +

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SECTION 16340

MEDIUM VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 SERVICE CONDITIONS

A. The range of ambient conditions are 0 degrees C to + 40 degrees C and the humidity range is 0% to 100%. The elevation is less then 3300 ft. The equipment is not exposed to damaging fumes, vapors, steam, salt air or oil vapors. The equipment is not exposed to excessive dust, abrasive dust, magnetic or metallic dust. The equipment is not exposed to explosive dust or gas. The equipment will not be exposed to abnormal vibration, shock or tilting beyond the seismic zone requirements of the design.

B. The equipment will be located indoors in a conditioned space.

1.2 SCOPE

A. It is the intent of this specification to provide a complete control and power distribution system for the operation of two (2) generators, rated 2400 volts and 2500 KW. All components, testing, and services specified or required for a complete operable system shall be included.

B. The paralleling switchgear and controls shall be the product of a single manufacturer and shall be provided in a single, integrated lineup. The switchgear shall consist of two (2) Generator sections, one (1) master and transition section, two (2) 2-high feeder sections, one (1) Utility main section, and one (1) metering section. This is an isolated bus that never parallels with utility.

C. Work under this Section shall be provided by the supplier of the standby generators specified in Section 16230, and shall be coordinated, installed, and tested as a complete system.

D. The switchgear shall be rated
   1. Voltage Class: 5KV
   2. MVA rating: 250
   3. Switchgear operating voltage: 2,400VAC
   4. Basic Impulse Level: 60KV
   5. Short Time Current Level: 36KAIC
   6. Close and Latch Level: 58KAIC

7. Switchgear Control Power
8. Battery Voltage: 125VDC
9. Breaker Close and Charge voltage: 125VDC
10. Breaker trip voltage: 125VDC

1.3 RELATED SECTIONS

A. Section 16230: Generators

1.4 APPLICATION CODES AND STANDARDS

A. The following standards are required as they apply to the equipment specified. Current code dates in effect at the time the contract is awarded shall be followed.
   1. American National Standards Institute, Inc. (ANSI)
      Institute of Electrical & Electronic Engineers (IEEE)
         C37.20.2 Switchgear Assemblies
         C57.13 Standard Requirements for Instrument Transformers
   2. UL Circuit breakers and Metal-Clad switchgear Over 600 Volts
      a. To provide for unit responsibility, each individual section of the switchgear lineup including engine/generator control sections, master control sections, main and feeder sections, with all internal components mounted, shall be UL listed an labeled under the generator control manufacturer's name.
      b. Manufacturers submitting equipment lineups without being listed and labeled per the above medium voltage UL standard shall not be acceptable.
   3. National Fire Protection Association (NFPA)
      a. NFPA 70- National Electrical Code – Current Edition
      b. NFPA 110 Standard for Emergency and Standby Power Systems
   4. National Electric Manufacturers Association (NEMA)
   5. State and Local Codes as applicable.

1.5 MANUFACTURERS QUALIFICATIONS

A. The equipment described, as a minimum, shall meet all of the requirements specified in this section. The equipment shall be the product of a manufacturer who has produced this type of equipment for a period of at least 15 years.

1.6 SUBMITTALS

A. Submittals for approval shall include the following:
   1. Elevation drawings with shipping splits identified.
   2. Outline drawing showing conduit entry areas and anchoring information.

3. Dimensioned layout and cabinet drawings
4. Single Line Diagram
5. Sequence of operation.
6. Bill of material showing major items to be supplied with manufacturer's name.
7. Manufacturer’s literature for all components
8. Complete nameplate schedule.

B. Operation and maintenance manuals shall be supplied per Division 1. The manuals shall contain:
1. Sequence of Operation
2. Installation Instructions
3. Maintenance Instructions
4. Material Summary
5. Complete Drawings
6. Component Instructions
7. Spare Parts Information

C. Final as-built information including 1 through 6 above, as well as interconnect diagrams showing termination points for external connections shall be submitted to be incorporated into the instruction manuals.

1.7 TESTING

A. The equipment shall be factory tested to simulate a complete and integrated system. The circuit breakers supplied shall be installed in their actual positions and electrically and mechanically tested. A narrative of the system operation shall be provided and shall be utilized when testing the equipment. Copies of the test reports shall be submitted to the Engineer.

B. The following separate tests shall be documented:
1. Dielectric Test (Per ANSI C37.20.2, 5.3.1)
2. Mechanical Test (Per ANSI C37.20.2, 5.3.2)
3. Grounding of Instrument Transformer Case Test (Per ANSI C37.20.2, 5.3.3)
4. Electrical Operation and Control Wiring Test (Per ANSI C37.20.2, 5.3.4.1)
5. Polarity Test (Per ANSI C37.20.2, 5.3.4.3)
6. Sequence Test (Per ANSI C37.20.2, 5.3.4.4)

1.8 WARRANTY AND SERVICE

A. The manufacturer shall warrant the equipment to be free from defects in material and workmanship for no less than one year from the date of project substantial completion.

B. Manufacturer shall have an established network of service centers capable of servicing the specified equipment.

C. Service center and manufacturer's personnel shall be on call 24 hours a day, 365 days a year. Personnel shall be factory trained and certified in the maintenance and repair of the specified equipment.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The equipment described is a medium voltage, integrated switchgear protection and control system as manufactured by ASCO Power Technologies. Russselectric is considered equal to the equipment specified. Costs incurred to modify the building and/or interfacing equipment which are affected as a result of an or equal substitution, shall be the responsibility of the equipment supplier.

2.2 GENERAL CONSTRUCTION

A. Switchgear Enclosure
   1. Metalclad type construction shall be used in the formation of the housing to provide a rigid self-supporting and self-contained freestanding assembly. Major components of the primary circuits, breakers, buses, and voltage transformers, are completely enclosed by grounded metal barriers, that have no intentional openings between compartments.
   2. Shipping sections shall be a maximum of two vertical sections with provisions for overhead lifting and forklift handling.
   3. All doors shall be pan type and be provided with sufficient hinges and stiffeners to support the door and components for an absolute minimum deflection and wobbling when opening or closing. Doors must operate more than 90 degrees.
   4. The primary switching devices (vacuum circuit breakers) are of the removable (drawout) type, arranged with a mechanism for moving it physically between connected, test, and disconnected positions, equipped with self-aligning and self-coupling primary disconnects.
   5. All vacuum circuit breaker housings shall be equipped with automatic shutters that cover primary circuit elements when the vacuum circuit breaker is in the disconnected, test, and removed position.
   6. Primary bus conductors shall be fully insulated and removable insulation boots shall be provided for all bolted joints.
   7. Instrument compartments and all low voltage wire-ways will be isolated from all primary circuit elements by grounded metal barriers.

8. All removable access covers that expose primary elements when removed, shall be marked with "DANGER HIGH VOLTAGE" warning labels.
9. A continuous copper ground bus shall extend the entire length of the switchgear with each individual section grounded by bolted connection. The copper ground bus shall be a minimum of 1/4 X 2-in. size with provisions for cable connections at each end of the switchgear assembly.
10. All circuit breaker ground pads shall be connected directly to the ground bus with bus bar of equivalent size.
11. Primary termination compartments shall be suitable for top or bottom cable entry as specified, with adequate space for stress cones and shielded cable ground lead terminations.
12. Where a two high vacuum circuit breaker configuration is provided, the termination compartments shall be isolated by grounded metal barriers and cable duct to isolate incoming cables from each cable compartment. Each cable compartment shall have a separate access cover to avoid exposing primary elements of the adjacent compartment.
    a. Structure: The enclosure shall be formed from 11 gauge sheet steel and shall meet the requirements for seismic zone 4, as outlined by the Uniform Building Code. Certificate of compliance is required.
    b. Layout: All equipment shall be arranged in a logical manner to facilitate ease of operation and maintenance of the equipment.
    c. Paint: The complete assembly shall be thoroughly cleaned and treated prior to painting. The unit shall be painted ANSI-61, light gray with a finish suitable for indoor or outdoor locations.
    d. Bus: Main bus shall be rated 3000 amps and shall be fabricated from silver plated copper. The maximum temperature rise allowed shall not exceed 65 degrees C over a 40 degrees C ambient. The bus shall be insulated as required to provide the ANSI C37.20 BIL levels as applicable. Bus bracing will withstand the rated MVA short circuit current.
    e. Wiring: Switchgear control wiring shall be 600 volt, 90 degrees C switchboard type SIS, minimum size No. 14. Use solderless compression type connectors for terminating all wires to devices requiring lugs. Devices designed for lug-less connections will not use lugs at those connection points. Current transformer terminations shall be ring tongue type. Other circuits shall be locking spade type applied with the proper tool. For wiring from supervisory and annunciator devices to terminal blocks, UL recognized wire smaller than 14 AWG may be used. Control wires shall be permanently numbered on both ends with the number visible. The low-level signal circuits shall be provided with shielded wire to minimize electromagnetic cross talk and interference.

Provisions shall be made for wires to pass between vertical sections. Wire-ways or holes between sections will be provided. Any opening that control wiring will pass through that might abrade wire will have a grommet.

Wiring shall not be spliced and shall be free of abrasions and tool marks. The wires shall be neatly bundled and shall be supported to prevent sagging or breakage from weight or vibration. Wiring bundles shall be contained in covered metal or plastic gutters.

All wiring to hinged doors shall be run through door plugs. Terminal blocks shall be provided for all external connections and they shall be readily accessible in an area not exposed to primary bus or cables.

f. Nameplates: Engraved laminated plastic nameplates having white letters on black backgrounds shall identify major components, vertical sections and breakers. Vertical sections shall have letters 3/8" high; other lettering shall be a minimum of 3/16" high. Nameplates will be attached with self tapping stainless steel screws.

g. Safety: Components shall be enclosed within grounded metal enclosures. Barriers will be provided to isolate major components as provided by ANSI C37.20. All control connections shall be terminated in accessible areas. Warning labels shall be provided with "DANGER HIGH VOLTAGE" for all access areas to power circuits.

h. Locks: Front doors shall be supplied with a lockable handle. All door locks shall be keyed alike to operate from a single key, and one key shall be supplied for each lock. Full height doors will utilize latching at three (3) points to secure the door firmly when closed. Keyed interlocks, when required, shall be supplied with one key in each required lock. One extra spare key of each type shall be supplied separately, tagged as: "Spare, store in a safe place to prevent bypassing interlocks".

B. Components

1. Indicating Instruments: Analog indicating instruments shall be switchboard type 4 1/2" square, 1% accuracy class, 250 degree movement.
2. Protective Relays: Door mounted protective relays shall be utility grade with semi-flush mounting and drawout cases. They shall have standard built-in test features and targets. They shall be supplied with any special tools and test plugs required for normal calibration and maintenance.
3. Instrument and Control Switches: Instrument and control switches shall be of the rotary type and the contacts shall be totally enclosed. The handles shall be of distinctive shapes to indicate their functions. Each switch shall be supplied with a titled escutcheon plate, suitably marked for each position. The switches shall have positive means of maintaining contact which shall be silver to silver with a wiping action. The circuit breaker switch shall be provided with a target to indicate the previous operation of the switch.

4. Instrument Transformers: Instrument transformers shall be indoor type with ratings coordinated with the load required per ANSI Standard C57.13. Primary and secondary fuses shall be provided for potential transformers. Potential transformers shall have a BIL rating that matches or exceeds the BIL rating for the switchgear. Potential transformers will be mounted on traveling platform with primary and secondary disconnects. Current transformers will be provided with shorting type terminal blocks.
5. Control Power Fuses (600 V class): Fuses shall be mounted in locations where they are readily accessible. Pull-out type fuses shall be provided for all primary circuits and shall be of the current limiting type. Three (3) spare fuses of each type and ampere rating (primary and secondary) used in this equipment shall be supplied separately but shipped with the equipment.
6. Terminal Blocks: Terminal blocks shall be suitable for ring tongue or spade terminals and provided with binding head screws, minimum size of screw 8/32. The terminal block rating shall be 600V.
7. Solid State Circuitry: Solid state controls, relays, timers or monitors shall meet the following specifications:

   Accuracy: +/- 2% of set point.

   Temp Range: - 40 degree C to +65 degree C (-40 degree F to 150 degree F)

   Protection: Transient overvoltage withstand of 1500 volts peak, 1m sec. time constant.

   Ratings: Current ratings to exceed application of devices. Devices shall be UL listed if available.

2.3 GENERATOR CIRCUIT BREAKER AND CONTROL SECTION

A. An individual section shall be provided for each engine/generator. Each section shall contain the generator breaker, metering, protective relaying and auxiliary devices associated with its respective engine generator set and shall include the following:
   1. Circuit Breaker
      a. The metal-clad switchgear shall include one vacuum circuit breaker, electrically operated, rated per section 1.2 with a continuous current rating of 1200A for each generator to switch the generator output on and off the bus.
      b. The vacuum circuit breaker element shall be complete with operating mechanism, auxiliary switches, and interlocks. A barrier shall separate the high voltage parts of the circuit breaker from the operating mechanism and control devices. The circuit breakers will be horizontal drawout type capable of being withdrawn. The primary disconnecting contacts will be silver plated copper.

c. The breakers shall be operated by a motor charged spring stored energy mechanism. The stored energy mechanism shall be accessible and will be charged normally by an electric motor but in an emergency may be charged by a manual handle.

d. Each circuit breaker shall contain three vacuum interrupters separately mounted. An integral contact wear gap indicator for each vacuum interrupter shall be visible. The breaker shall be removable from the switchgear for ease of inspection and maintenance.

e. The secondary disconnecting device shall provide connections for the control circuits between the circuit breaker unit and the housing. The secondary disconnect shall automatically engage when the circuit breaker is placed in the "operating" position and be re-engaged manually when the unit is in the "test" position, without using a test jumper.

f. The breaker unit shall be moved between the "test" position and "operating" position by means of a levering device that is operated by a removable hand crank. The levering device shall be mechanically interlocked with the breaker closing mechanism so that a closed breaker cannot be removed from the "operating" position or cannot be closed when the levering device is between the "operating" position or the "test" position.

g. Interlocks will be provided to trip breakers upon insertion or removal from housing and to discharge stored energy mechanisms upon insertion or removal from the housing. The breaker will be secured positively in the housing between and including the operating and test positions.

h. A mechanical means shall be provided to prevent over-tightening a breaker when levered into the compartment.

2. Engine Starting Control

a. The engine starting control logic shall be microprocessor (PLC) based and shall automatically start, protect and monitor each engine generator set. Electro-Mechanical controls are unacceptable. A separate GE Versamax PLC shall be furnished for each engine generator and shall include a communication card, for Modbus RTU-485 Serial communication. The engine starting control logic shall be capable of controlling engines furnished with the following:

1) Starting motor magnetic switch.
2) Electrically operated fuel control.
3) Normally open protective switches (dry contact) that close for abnormal conditions of pressure, temperature, speed and liquid level when required.

b. The engine starting control logic shall provided through the Modbus RTU connection with the generator control panel. Electrically isolated (dry contact) contacts for electronic governor control, electric fuel control, battery charger disconnect during cranking and common shutdown alarm annunciations shall also be provided.

c. Five Position Engine Control Switch Operation

1) Stop/Reset: In this position, the engine shall not be capable of starting and/or running. If the engine was shutdown due to the operation of a protective device, the shutdown malfunction shall be reset when the switch is moved to this position. If the engine is running when the switch is moved to this position, it shall be immediately shutdown.
2) Off/Cooldown: In this position, the engine shall shutdown after a cooldown period (programmed at the generator control panel).
3) Automatic: In this position, the engine control shall be in readiness for fully automatic operation upon receipt of a start signal.
4) Test Off-Line: When placed in this position, the engine shall start and run as if a start signal were received except it shall not be connected to the bus unless a start signal is received. When returned to the automatic position, the engine will shut down.
5) Test On-Line: When placed in this position, the utility breaker shall close, the engine shall start, run and connect to the bus as if a start signal were received. When returned to the "Automatic" position, the circuit breaker will open and the engine will run for its cooldown period before shutting down.

C. Digital Synchronizer and Load Control (DSLC)

1. Each engine generator section shall be provided with a Woodward Digital Synchronizer and Load Control (DSLC). This unit contains the following features, as a minimum:
   a. Load Sensor/KW Load Sharing
   b. Gen Phase and Voltage Matching Sync
   c. Dead Bus Closing
   d. Automatic Gen Loading Controller
   e. Import/Export Control
   f. VAR/PF Control

D. Synchronizing Mode Selector Switch

1. Permissive: In this position the governor raise/lower controls are deactivated. However, the synchronizer can operate as a passive synch check relay and signal the closing of the generator breaker.

2. Check: In the position the synchronizer is fully operational except it can not close the generator breaker. The phase-lock feature shall hold the generator output in synchronism with the bus.
3. Off: In this position the synchronizer is turned off to allow manual paralleling at the Master Cubicle.
4. Run: In this position, the synchronizer is in the fully operational, automatic mode.

E. Alarm and Status Indication
1. Visual and audible alarm and status indication shall be provided on each generator control section to include readout and annunciation for:

FUNCTION:	COLOR:
SHUTDOWNS	
Low Oil Pressure	Red
High Water Temperature	Red
Overcrank	Red
Overspeed	Red
Reverse Power	Red
Circuit Breaker Trip	Red
PREALARMS	
Low Oil Pressure	Amber
High Water Temperature	Amber
ALARMS	
Fail to Synchronize	Red
Control Not in Automatic	Red
Control Voltage Failure	Red
PLC Stopped	Red
Circuit Breaker Close Failure	Red
Circuit Breaker Trip	Red
STATUS	
Paralleling Circuit Breaker Open	Green
Paralleling Circuit Breaker Open	Red
Auto Start	Amber

F. Generator Metering/Instrumentation

1. A multifunction digital meter shall be provided at each Generator Circuit Breaker and Control Section for generator metering. The digital meter shall be listed to UL 3111-1, CSA, CE Mark and industrially rated for an operating temperature range of –20°C to 60°C. It shall be accurate to 1% measured, 2% computed values and display resolution to .1%. Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions (harmonics). The digital meters shall be capable of operating without modification at nominal frequencies of 45 to 66 Hz and over a control power input range of 20 – 32VDC. Each meter shall include a communications module to permit information to be sent to the central monitoring computer for display, analysis and logging. The digital meter shall accept inputs from industry standard instrument transformers (120VAC secondary PT's and 5A secondary CT's). Direct phase voltage connections, 600VAC and under, shall be possible without the use of PT's.
2. Setup for system requirements shall be allowed from the front of the digital meter. All setup parameters required by the device shall be stored in non-volatile memory and retained in the event of a control power interruption. All setup and reset functions shall have a means for protection against unauthorized/accidental changes.
3. The digital meter shall be equipped with a continuous duty, long life 4 line x 20 character LCD backlit display. Displaying each of the measured quantities shall be accomplished through the use of menu scroll buttons. The following metered readings shall be displayed and communicated by the digital meter via serial communication:
    a. Current, per phase RMS and neutral
    b. Current unbalance %
    c. Voltage, phase to phase and phase to neutral
    d. Voltage unbalance %
    e. Real power (KW), per phase and 3-phase total
    f. Apparent power (KVA), per phase and 3-phase total
    g. Reactive power (KVAR), per phase and 3-phase total
    h. Power factor, 3-phase total & per phase
    i. Frequency
    j. Accumulated energy (MWH, MVAH and MVARH) – Reset of accumulated energy parameters shall be allowed from the front of the Data Monitor.
4. Digital meters shall be equipped with the following I/O: eight (8) solid state status inputs, four (4) relay output contacts.
5. The multifunction digital meters shall be the ASCO Power Manager or approved equal.

G. Failure to Synchronize Reset Switch: A momentary push-button switch shall be provided to reset the "Fail to Synchronize Alarm".

H. Engine Governor, Generator Voltage Regulator and Miscellaneous Engine Generator Set Controls: The supplier of the standby generator and paralleling system shall mount and wire all electronic and electric controls associated with the engine generator set governor and/or voltage regulator as described in the engine generator set specifications. These controls shall be furnished by the engine generator set distributor to the switchgear manufacturer for mounting and wiring. The controls may include, but not be limited to the following:
   1. Electronic control portion of governor
   2. Voltage regulator
   3. Motorized voltage adjust potentiometer
   4. Crosscurrent compensation transformer

I. Protective Relays:
   1. Generator protection shall be provided using a multifunction generator management relay (GE/Multilin SR489) with complete protection, metering and monitoring functions. The settings for the protective devices shall be determined in accordance with the protective device coordination study and the short circuit study specified in other sections of these Specifications. The protection functions shall include:
      a. Instantaneous overcurrent when off-line (50)
      b. Instantaneous and definite time overcurrent for ground (50/51N)
      c. Stator thermal modeling and RTD (49)
      d. Negative Sequence overcurrent (46)
      e. Bearing overtemperature (38)
      f. Phase differential (87G)
      g. Over/under voltage (27/59)
      h. Reverse power (32)
      i. Over/under frequency (81 O/U)
      j. Overexcitation (24)
      k. Loss of field (40)
      l. Inadvertent generator energization (50/27)
      m. Overspeed (12)
      n. Voltage restrained phase overcurrent (51V)
      o. 100% Stator ground protection (59GN/27TN)
      p. Bearing vibration (39)
      q. Voltage phase reversal (47)
      r. VT fuse failure detection (60FL)
      s. Breaker failure detection (50BF)
      t. Trip coil supervision
      u. Sequential tripping logic
   2. Monitoring and metering functions shall include:

a. RMS current, negative sequence current, voltage, three phase power, temperature (via 12 RTD inputs) and four analog inputs.
b. Four analog output channels which can be configured to any measured parameter.
c. An event record which shall maintain a record of the last 40 events.

3. The current and voltage inputs shall be sampled 12 times a cycle. The relay shall store sixteen cycles in the event of a trip.
4. The protective relay shall include the following user interfaces:
   a. A 40 character vacuum florescent display, control keys and full numeric keypad located on the front panel.
   b. LED indicators located on the front panel which shall indicate the status of the protection relay, generator and output relays.
   c. An RS232 port located on the front panel with a baud rate of 9600 bps.
   d. Two RS485 ports located on the rear of the unit with baud rates from 300 to 19,200 bps.
   e. The communications ports shall allow simultaneous independent access using Modbus RTU protocol.
   f. Windows based PC software which enables setpoint programming, file storage, on-line help and real time display of status and measured data.
5. The protective relay shall be provided with drawout construction to facilitate testing, maintenance and interchange flexibility.

J. Additional Devices and Controls
1. Current and Potential transformers, as required for metering, relaying and control.
2. Three additional current transformers (for generator differential relay) shall be supplied loose for mounting at the generator terminal box.
3. Circuit breaker trip switch with two position indicating lights, LED type
4. Device 86, lockout relay, LOR
5. Any other control devices or indications necessary to make the system perform as required shall be included.

2.4 MASTER CONTROL SECTION

A. The master control section shall contain a industrial-based programmable logic controller, General Electric Series 90-30 PLC, capable of storing the necessary control sequence algorithms, variable operation set-points, time delays, and alarming levels. Discrete input/output cards shall provide a modular interface for digital, analog, and RTD monitoring and controls necessary to provide for integrated system operations as specified in section 3 Description of Operations.
1. Load Control
   a. The following load shedding scheme shall be a function of the master controls, but shall not be utilized for this project.

b. Discrete output relays shall be provided to control the necessary loads.
c. The generator bus shall have a solid-state frequency monitor (Device 81U), with integral time delay to initiate load shedding upon a reduction of bus frequency to 58 Hz or less for a period of two seconds or more. Upon sensing a bus underfrequency, the system shall automatically shed the lowest priority load connected at the time of occurrence. This shed circuit shall override any manual load-add operation and shall lock out the manual load-add circuitry. It shall give visual and audible alarm annunciation of bus underfrequency load shed.
d. Provide a "bus underfrequency reset" push-button to reset bus underfrequency load shed signal.
e. Provide a "load shed bypass/reset" push-button, for manual supervised operation over the load-shed, load-add control logic. One push-button shall be provided for each priority block except first priority. Logic shall be provided so that in the event a bus overload occurs resulting in a reduction in bus frequency, the bypassed priority load shall be shed automatically through override logic control.

2. Manual Paralleling Controls
   a. A Paralleling selector switch shall be provided to select any generator for manual paralleling operation. The positioning of the selector switch shall simultaneously connect the synch-check relay, synchroscope, and "manual paralleling" push-button of the selected generator to the generator bus.
   b. The solid-state device 25C, shall be furnished as a sync check relay for manual paralleling to sense and compare the phase angle difference between the oncoming generator and the bus. This relay shall lockout the manual paralleling push-button until the oncoming generator is within 15 degrees of synchronism.
   c. Operation shall be arranged so that the operator shall depress and hold the manual paralleling push-button. When the relative phase angle reduces to 15 degrees and going towards zero degrees, the device 25C's output contact shall initiate the closing of the respective oncoming generator breaker.
   d. All manual paralleling interface controls and metering shall be grouped in a central location on the front of the master control section. This shall allow for multiple generators paralleling from one location within the switchgear.
3. Master Control Programmable Logic Controller (PLC)
   a. The master control PLC shall maintain the following:

1) The CPU shall have a minimum of 16K/Bytes capable of storage on random access memory (RAM), erasable programmable read only memory (EPROM), or electrically erasable programmable read only memory (EEPROM). RAM memory shall be backed up with a lithium battery for protection during voltage loss and spare parts capabilities.
2) The CPU shall also be capable of supporting I/O and CPU fault diagnostics. This shall consist of CPU failure detection, watch-dog timer error, I/O modular failure, and battery failure.
3) The CPU shall have an execution speed of 4 milli-seconds per 1000 words of ladder logic programming.
4) The PLC shall have the capability to utilize up to 1024 discrete I/O pints and 2048 memory registers.
5) The PLC shall have the capability to interface to a remote I/O rack via RS-485 serial communication.
6) The PLC shall be equipped with an Ethernet port and shall be capable of communicating via Ethernet/IP either natively or through a protocol converter. All information capable of being displayed on the Operator Interface shall be available via Ethernet.
7) Provide a managed DIN rail mountable Ethernet switch with one port reserved for connecting to the Owner's SCADA system

4. Operator Interface.
   a. A microprocessor-based video display panel shall be supplied allowing facility operators the ability to change operational set-points and time delays. The video panel shall be a 15-inch video display terminal using Wonderware software. The video panel shall be compatible with major PLC brands, and connect directly to the PLC/CPU communication port over RS-422 communications or Ethernet communications over TCP/IP.
5. Alarm and Status Indication
   a. Visual and audible alarm and status indication shall be provided on the master control section to include readout and annunciation for:

FUNCTION:	COLOR:

STATUS		
Manual Paralleling Available		Green
Bus Underfrequency Alarm		Red
Load Shed Circuits (One for each priority)	Activated	Amber
Load Shed (One for each priority)	Bypass	Amber
Gen #_ (One for each Engine Generator)	Running	Green
Gen #_ On (One for each Engine Generator)	Line	Green
Gen #_ (One for each Engine Generator)	Lockout	Red
System PLC Stopped		Red
PLC Power Source Failure		Red
Emergency Mode		Amber

6. Master Audible Alarm
   a. Provide a master audible alarm. The alarm horn shall be the DC vibration type, subsequent malfunctions to resound the alarm if the horn had been previously silenced following an initial malfunction.
7. DC Control Power Selector -- Best Battery System
   a. Control power for the system logic shall be derived from the paralleling gear starting batteries. The control logic shall be powered through a suitable means which shall permit continuity of power until the last battery is no longer available. The controls shall be powered from any battery or combination of batteries and prevent feedback to a failing battery. The transition of control logic power from any battery combination to any other battery combination shall be accomplished without disruption in the power flow. PLC power supply utilizing a specially designed DC-to-DC converter shall provide a backup 24 VDC power supply to the generator and master programmable logic controllers (PLCs) during starting and cranking all engine generator sets “simultaneously”.
8. System Test Switch
   a. Provide a system no-load test switch to initiate a complete automatic system operation by simulating the closure of the remote engine start signal. This switch shall be mounted inside the master section to limit access to authorized personnel only.
9. Manual Paralleling Instrumentation
   a. Two analog Voltmeters
   b. Two analog Frequency Meters
   c. Analog Synchroscope

d. Paralleling Selector Switch
e. Manual Paralleling Pushbutton
f. Sync check relay
g. ASCO Power Manager Xp Digital Meter

10. Additional Controls
    1. Current and Potential transformers, as required
    2. Any other control devices or indications necessary to make the system perform as required shall be included.

2.5 UTILITY MAIN BREAKER SECTION

A. Circuit Breaker: Utility main vacuum circuit breaker, 3000 amp rated per section 1.2, electrically operated, drawout type construction, with auxiliary contacts. Breaker shall be the same type and manufacture as the generator breakers.

B. Utility Line Metering/Instrumentation
   1. Digital multifunction metering device shall be the same type and manufacture as the generator digital meters.

C. Master Synchronizer and Load Control (MSLC)
   1. The utility main breaker section shall be provided with a Woodward Master Synchronizer and Load Control (MSLC) for system synchronizing and control. The MSLC has the following features, as a minimum:
      a. Gen Bus Phase and Voltage Matching Sync
      b. Utility Load Sensor
      c. Import/Export Load Level Control
      d. System Power Factor Control
      e. Master Process Control

D. Protective Relays
   1. Utility protection shall be provided using a multifunction feeder management relay (GE/Multilin SR750) with complete protection, metering and monitoring functions. The protection functions shall include:
      a. Synchrocheck (25)
      b. Over/under voltage (27/59)
      c. Reverse power (32)
      d. Negative sequence voltage (47)
      e. Instantaneous and time overcurrent (50/51)
      f. Instantaneous and definite time overcurrent for ground (50/51N)
      g. Over/under frequency (81 O/U)
      h. Directional overcurrent, phase/neutral (67)
      i. Trip coil supervision
   2. Monitoring and metering functions shall include:

a. RMS current, negative sequence current, voltage, three phase power and 14 contact inputs.
b. Eight relay outputs.
c. An event record which shall maintain a record of the last 128 events.

3. Waveform capture shall be provided with storage of up to 128 cycles of data.
4. The protective relay shall include the following user interfaces:
   a. A 40 character vacuum florescent display, control keys and full numeric keypad located on the front panel.
   b. LED indicators located on the front panel which shall provide a quick indication of status.
   c. An RS232 port located on the front panel
   d. Two RS485 ports located on the rear of the unit
5. The protective relay shall be provided with drawout construction to facilitate testing, maintenance and interchange flexibility.

E. Additional Devices
1. Current and Potential transformers, as required.
2. Circuit breaker control switch with two position indicating lights
3. Relay output to indicate main breaker position
4. Device 86, lockout relay, LOR
5. Any other control devices or indications necessary to make the system perform as required shall be included.

2.6 TWO HIGH FEEDER BREAKER SECTION

A. Each two-high feeder section shall be provided with two of each of the following:
1. Circuit Breaker: Feeder vacuum circuit breaker, 1200 amp rated per section 1.2, electrically operated, drawout type construction, with auxiliary contacts. Breaker shall be the same type and manufacture as the generator breakers.
2. Feeder Breaker Metering/Instrumentation
   a. Metering device shall be the same type and manufacture as the generator digital meters.
3. Protective Relays
   a. Device 50/51, three phase overcurrent relay, utility grade, GE Multilin SR-735
   b. Device 51N, residual phase ground overcurrent relay, utility grade, GE Multilin SR-735
4. Additional Devices
   1. Current and Potential transformers, as required.
   2. Circuit breaker control switch with two position indicating lights
   3. Device 86, lockout relay, LOR
   4. Any other control devices or indications necessary to make the system perform as required shall be included.

2.7 STATION BATTERY SYSTEM

A. Charger: The battery charger shall be rated for 20 Amps at 24VDC output, with 120VAC single phase input voltage. The charger will be provided with input and output circuit breakers. It will have two rate type with a regulated output voltage stability of +/- 1% from zero to full nominal rating over an input voltage variation of 10%. The charger shall include front-panel-mounted meter to display volts, amps and hours, float charge indicator and high rate charge indicator. The charger shall also be equipped with failure alarm relay. The battery charger shall be UL listed.

B. The storage battery shall be lead-acid, designed for nominal 24VDC switchgear service and shall be capable of delivering a 160 ampere hour capacity at the 8 hour rate, or as capacity as required at the 8 hour rate based on battery calculations submitted and reviewed by the Engineer.

C. The battery system shall be supplied with a battery rack suitable for floor mounting.

PART 3 - EXECUTION

3.1 NORMAL CONDITION

A. Under normal conditions, all of the generator breakers, and the gen paralleling breakers will be open, and the engine/generators will be shut down. The utility main breaker will be closed. The utility source will be supplying all of the load through the normal distribution system.

3.2 LOSS OF UTILITY

A. Upon a loss of normal source voltage at the utility main breaker (after an adjustable time delay), the main breaker will open and a signal will be generated and transmitted to the generator control switchgear to initiate an automatic sequence.

B. Upon initiation of the automatic sequence, all engines will be started. The first engine generator set to achieve 90% of nominal voltage and frequency will be connected to the bus through the multiple circuit interlock discriminator. The remaining generators will automatically synchronize and be paralleled to the emergency bus by closing their circuit breakers. Alternate source indication will be provided to the plant SCADA system for equipment lockout. The failed utility source breaker has opened, and the associated generator main breaker will close in an open transition, break-before-make transfer. The connected loads will now be powered by the generator bus. If any engine generator fails during standby operation, the lowest priority loads will be immediately shed through the plant SCADA system.

C. Upon restoration of the normal source, the generator system will open the generator connection breaker and close the utility main breaker after an adjustable time delay of 0-30 minutes. Upon re-transfer of all loads, the engine generator sets will be disconnected from the bus, run for an adjustable period (factory set at 15 minutes) for cooldown and then shutdown. All controls will automatically reset for the next automatic operation.

3.3 LOAD DEMAND

The following describes the required capability of the system to provide control of the standby generators during periods of low load conditions. It is not intended that these controls be put into operation for this project.

A. After all generator sets have been paralleled to the bus and all loads connected, a stabilization time delay (0-15 minutes) factory set at 15 minutes will be initiated. At the expiration of the time delay period, the system will operate in a load demand mode. The Load Demand Control Logic and its associated controls will control the number of generating sets on the bus, such that the on-line reserve capacity of the bus is not less than 10%, nor more than 120%, of the capacity of a single generator set.

B. Upon sensing that the connected load has decreased the reserve capacity to 10% or less, a 10-second time delay is initiated. This time delay will be field adjustable from 0-300 seconds. If the reserve capacity stays below 10% for the duration of the 10-second time delay, the controls will initiate the starting and paralleling of the next set in sequence. If, during the time delay period, the reserve capacity decreases to 0 or less (signifying bus overload), the time delay will be bypassed and the next set in sequence will be immediately started and paralleled. At the same time, a lamp indicating a bus overload will light and signals will be given to shed loads such that the connected priority blocks of load are reduced to equal the number of engine generator sets on line. When the next set is paralleled to the bus, the shed load will be reconnected and all controls automatically reset.

C. Should the next set in sequence have its engine control switch in the "off" position or fail to synchronize within the preset time delay of the "fail-to-synchronize" timer, the controls will automatically pass the starting signal to the next set in sequence. Individual visual and audible alarms will initiate the above conditions.

D. If while operating in the load demand mode, an engine generator set malfunction occurs, the affected set will be removed from the bus and load priority blocks will be shed such that the remaining priority blocks are equal to the capacity of the remaining engine generators. All idle sets will be started and paralleled. As the sets are paralleled, all loads will be reconnected except for the last priority block which cannot be fed when a generator is down. These loads may be added manually by an operator if it is determined that it will not overload the system. The stabilization time delay is energized after all available sets have been connected to the bus, and, upon its expiration, load demand operation is resumed.

E. Upon sensing that the on-line reserve capacity has increased to 120% or more, a 180 second (adjustable 0-300 seconds) time delay will be initiated. If the reserve capacity stays above 120% for the duration of the time delay, the circuit breaker of the last set that went on line will be opened. The engine will run for its cooldown period, then shutdown.

F. An operator interface panel shall be provided on the Master Control Section to allow changes to the engine generator start/stop sequence.

3.4 BUS LOAD OPTIMIZATION

The following describes the required capability of the system to provide control of the standby generators during periods of low load conditions. It is not intended that these controls be put into operation for this project.

A. Provide control logic to allow loads, which have been shed because of a generator failure, to be automatically readded to the emergency bus in discrete load increments until the bus has been loaded to 95% of its capacity.

B. If a generator fails while operating in the emergency mode, it is disconnected from the bus and shutdown. The lowest priority loads are shed. Audible and visual alarms shall be activated to indicate the condition. After a stabilization period, (user adjustable, 0-9999 minutes), the shed loads shall be automatically readded to the emergency bus in discrete load increments until the bus has been loaded to 95% of its capacity.

C. If at any time the bus is overloaded greater than 115% of the bus capacity, or if the bus frequency drops to 58Hz or less for more than two seconds, then all bus optimizing loads as well as the lowest priority supported load block connected to the bus are shed. A status light indicating a "Bus Overload" shall be activated and the alarm horn sounded. The bus overload control is maintained until examined by the plant operator. After taking appropriate actions, the condition may be reset via the "Bus Overload Reset" push-button.

3.5 STARTUP AND INSTALLATION

A. The manufacturer of the generator control switchgear shall provide the services of a factory trained technician to provide installation assistance.

B. It shall be the responsibility of the installing contractor to verify that the following items have been completed and are ready to perform as specified before the arrival of the factory technician.
   1. Inspect for obvious shipping damage.
   2. The switchgear is installed, anchored down and grounded.
   3. Shipping splits have been reinstalled with the splits bolted together, interconnect wiring installed and bus splice plates installed.
   4. Terminate all power cables.
   5. Install customer control wiring to external equipment including engines, batteries, associated motor control, etc.
   6. The engine generator set is installed and ready to run.
   7. Associated motor controls, plumbing, building utilities are complete and operational.

C. The Factory Technician shall perform the following series onsite:
   1. Verify contractor connections, control power availability, visually inspect relay settings, verify megger test of the generator cables and the main bus.
   2. With the engine generator supplier's technical representative controlling the engine, verify that the switchgear and control equipment are fully operational and perform per the sequence of operation specified. Equipment or services required for load or performance testing of the engines shall be provided by the engine generator set supplier.

3. With the engine generator supplier's technical representative controlling the engine, demonstrate all functions of the control system, both automatic and manual, to the satisfaction of the approving engineer.
4. Provide documentation in the form of function checklists and recorded data for each section to the Engineer.

+ + END OF SECTION + +

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SECTION 16342

MEDIUM VOLTAGE MOTOR CONTROL

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes
   1. This specification covers the design, manufacture, test, supply and delivery of medium voltage controllers

1.2 QUALIFICATIONS

A. Manufacturer
   1. The manufacturer shall have a minimum of 10 years experience in the manufacture of medium voltage controllers for use in similar applications at the specified voltage and power ratings.
   2. These specifications are based on products manufactured by Allen Bradley.

B. Support
   1. The manufacturer shall maintain factory trained and authorized service facilities within 100 miles of the project and shall have a demonstrated record of service for at least the previous ten years.
   2. Support personnel are to be direct employees of the manufacturer.
   3. The manufacturer shall provide all required start-up and training services.

C. Quality Assurance
   1. The control center shall be factory pre-wired, assembled and tested as a complete package by the controller supplier.
   2. All inspection and testing procedures shall be developed and controlled under the guidelines of the Supplier's quality system. This system must be registered to ISO 9001 and regularly reviewed and audited by a third party registrar.
   3. All incoming material shall be inspected and/or tested for conformance to quality assurance specifications.
   4. All sub-assemblies shall be inspected and/or tested for conformance to Supplier's engineering and quality assurance specifications.
   5. All printed circuit boards with active components shall be burned-in for a minimum of 48 hours at 60ºC (140°F).

1.3 REFERENCES

A. Controller

1. American National Standards Institute (ANSI) "Instrument Transformers C57.13"
2. Institute of Electrical & Electronic Engineers (IEEE) (IEEE C37.20.7, Guide for Testing Arc Resistant Medium Voltage Switchgear)
3. Electrical & Electronic Manufacturers Assoc. of Canada (EEMAC)
4. National Electrical Manufacturers Association (NEMA) "Medium Voltage Controllers Rated 1501 to 7200V AC ICS 3-2 (formerly ICS 2-324)"
5. Underwriters Laboratories, Inc. (UL) (High Voltage Industrial Control Equipment 347)
6. European Directives for Safety and EMC
7. National Electrical Code (NEC)
8. Occupational Safety & Health Act (OSHA)

1.4 ENVIRONMENTAL REQUIREMENTS

A. Confirm to specified service conditions during and after installation of products

B. Maintain area free of dirt and dust during and after installation of products

1.5 PRE-MANUFACTURE SUBMITTALS

A. Refer to Section Division 1 for submittal procedures

B. Drawings
   1. Elevation drawings showing dimensional information
   2. Structure Descriptions showing
      a. Enclosure ratings
      b. Fuse ratings
      c. Load/line cable size and entry/exit direction
      d. Other information as required for approval
   3. Conduit locations
   4. Unit Descriptions including amperage ratings, frame sizes, pilot devices, etc.
   5. Nameplate Information
   6. Schematic wiring diagrams

C. Product Data
   1. Publications related to the controller(s)
   2. Data Sheets and Publications on all major components such as the following
      a. Contactors
      b. Circuit Breaker and Fuse information including time current characteristics
      c. Control Power Transformers
      d. Pilot devices
      e. Relays
      f. Operator Interface

D. Spares
   1. Recommend spare parts list and list prices shall be supplied.
   2. Critical Spares - Spare parts that are identified as being associated with long lead times and/or are critical to the unit's operation.
   3. Maintenance Spares - Spare parts that are identified as being required to regularly perform scheduled maintenance on their equipment. These spares include, but are not limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.

E. Specification Response
   1. Detailed response to this specification showing where in the literature and drawings each requirement is satisfied.
   2. All clarifications and exceptions must be clearly identified.

F. Testing and Test Reports
   1. Testing shall be per manufacturer’s standard.
   2. A copy of the test reports shall be provided as part of the Closeout documentation, if requested.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section Division 1 for procedure on submittal of closeout documentation.

B. Contractor shall provide certification that the controller has been installed in accordance with the manufacturer’s instructions.

C. The Contractor shall provide certification that the Contractor has properly adjusted any timing devices required in the starting circuitry.

D. Final Drawings. The manufacturer shall provide final drawings reflecting the “As-Shipped” status of the controller. The Contractor shall be responsible for making any changes to the “As-Shipped” drawings from the manufacturer to reflect any field modifications.

E. Maintenance Data
   1. Controller installation instructions and User Manual
   2. Installation / Operation instructions for major components such as circuit breakers, contactors, isolation transformers, etc.
   3. Field Service report from start-up service
   4. Spare parts listing and pricing
   5. Include name and phone number for a local distributor of spare parts.

1.7 DELIVERY, STORAGE AND HANDLING

A. Contractor shall coordinate the shipping of equipment with the manufacturer.

B. Contractor shall store the equipment in a clean and dry space according to manufacturer's specification.

C. The contractor shall protect the units from dirt, water, construction debris and traffic.

1.8 FIELD MEASUREMENTS

A. The Contractor shall verify all field measurements prior to the fabrication of the controller(s).

1.9 SPARE MATERIALS BILL OF MATERIAL

A. Fuses
   1. Provide a minimum of one set (3) of each type of medium voltage fuse supplied with the controller for each set of five installed.
   2. Provide a minimum of one set of each type of low voltage fuse supplied with the controller for each set of five installed.

B. Contactors
   1. Provide one set of 3 contactor vacuum bottles for each size of medium voltage vacuum contactor supplied with the controller.
   2. Provide one spare vacuum contactor control module (IntelliVAC).

C. Isolation Switch
   1. Provide one spare isolation switch blade assembly for each amp rating installed.
   2. Provide one spare isolation switch auxiliary contact for each set of five installed.
   3. Provide one spare isolating switch cam follower for each type installed.
   4. Provide one spare isolating switch stationary stab for each amp rating installed.

D. Provide one spare motor protection relay for each type supplied with the controller.

E. Provide one spare overload relay supplied with the controller.

F. Provide one spare control relay for each type of relay supplied with the controller.

G. Provide one spare MOV assembly of each type supplied with the controller.

1.10 WARRANTY

A. The manufacturer shall provide their standard parts warranty for a minimum of one year from the date of project Substantial Completion.

B. The manufacturer shall confirm this warranty as part of the submittal.

PART 2 – PRODUCTS

2.1 RATINGS

A. Voltage
   1. The controller shall accept nominal plant power of 2400V at 60Hz.
   2. The supply input voltage tolerance shall be plus or minus 10 percent of nominal line voltage.
   3. The supply frequency tolerance shall be plus or minus 3 percent.

B. Environmental Ratings
   1. Storage ambient temperature range: -20 C to 75 C (-4 to 149 degrees F).
   2. Operating ambient temperature range: 0 C to 40 C (32 to 104 degrees F) without derating.
   3. The relative humidity range is 0% to 95% non-condensing.
   4. Operating elevation: up to 1,000 Meters (3,300ft) without derating.

2.2 STRUCTURE

A. The structure shall consist of a metal enclosed free-standing dead-front vertical steel assembly.

B. The structure shall also have a non-removable base channel and removable lifting means for ease of installation.

C. The controller(s) shall be designed for front access to allow for installation with no rear access. Equipment that requires rear or side access for installation shall not be accepted.

D. Enclosure
   1. Controller enclosures shall be NEMA Type 1A, with door gaskets
   2. The enclosure shall be properly sized to dissipate the heat generated by the controller at its full ratings within the limits of the specified environmental operating conditions.
   3. LV door latches shall be heavy-duty ¼-turn type units.
   4. Medium Voltage doors shall be held closed using 3/8” bolts.
   5. All back plates shall be removable.

E. Low Voltage Wireway
   1. A low voltage wireway, shall be available across the roof at the front of the structure.

2. The low voltage wireway shall provide a convenient method of interconnecting control wire from one controller to another.
3. Low voltage wireway shall be separated from MV and LV control compartments.

F. Structure Finish
1. All exterior metal parts (except for low voltage panel and power cell back plates) shall be painted with hybrid epoxy powder paint ANSI 49 medium light gray.
2. All mounting plates in the power cell and low voltage compartments shall be painted high gloss white for enhanced visibility.
3. Painting shall be done on a continuous paint line through air-atomized electrostatic spray. All parts shall be painted before assembly.
4. The preparation shall be Alkaline wash/rinse; iron phosphate rinse; iron-chrome sealer rinse; re-circulated de-ionized water rinse and virgin de-ionized water rinse
5. Total paint thickness – 0.002" (0.051 mm) minimum
6. Baking process shall be by Natural gas oven at 179°C (355°F) minimum.
7. All unpainted steel parts shall be plated with a zinc plate/bronze chromate process for corrosion resistance.

G. Nameplates
1. Provide master nameplate for controller.
2. Provide unit nameplates.
3. Provide legend plates for all pilot devices.
4. Nameplates plates shall be engraved phenolic (1.125 inches x 3.625 inches) with black background and white lettering.

H. Seismic Qualifications
1. The equipment shall be bolted down (mounted) per the Manufacturer's recommended installation instructions.
2. The properly installed equipment shall be capable of withstanding horizontal and vertical accelerations in accordance with KBC requirements, without overturning or lateral movement.

2.3 POWER AND GROUND BUS

A. Bus Bracing
1. The horizontal/vertical buswork and the cabling/bus in the main power cell(s) shall be braced and tested in accordance with NEMA ICS 3-2 and UL 347.
2. The bus work and cabling shall be braced to withstand the let-through energy allowed by the largest fuse during a short circuit fault.
3. The horizontal bus fault withstand current rating shall be 60 kA RMS symmetrical for 10 cycles.

4. The vertical bus fault withstand current rating shall be 50 kA RMS symmetrical for one half cycle.

B. Horizontal Bus
   1. The main horizontal power bus shall be located in the center, at the back of the structure, to provide optimum heat distribution, ease of maintenance and splicing.
   2. To provide better short-circuit withstandability and to protect against the accumulation of dust and tracking between phases, the power bus shall be mounted on edge to a molded bus support insulator in a common vertical plane.
   3. The power bus shall be made of tin-plated copper and shall have a continuous current rating of 2000A. The main power bus will be non-insulated.
   4. Access plates shall be provided to the bus compartment from the front or the rear of the structure to allow for installation and regular maintenance of the power and ground bus splice connections.
   5. The horizontal buswork, the cabling/bus from the main power cell shall be braced and tested in accordance with NEMA ICS 3-2 and UL 347 (paragraph 30).

C. Vertical Bus
   1. Provide vertical power bus risers from the main horizontal power bus to the isolating switch line terminals.
   2. The vertical risers shall be tin-plated copper.
   3. Cabling from the main horizontal power bus to the isolating switch is not acceptable.

D. Ground Bus
   1. A continuous copper ground bus shall be provided along the entire length of the controller line-up.
   2. A mechanical lug for #8 to #1/0 AWG or #6 to 250 MCM cable shall be supplied at the incoming end of the line-up.
   3. The ground bus shall be 1/4" x 2" (6.4 x 51 mm), bare [tin-plated] copper.

2.4 MAIN UNIT

A. The withstand rating of the main shall be greater than or equal to the bus bracing for the controller.

B. Provide lugs to accommodate the line conductors as indicated on the drawings.

C. Provide metal oxide station type surge arrestors.

2.5 FEEDER DISCONNECT

A. Provide feeder disconnects with overcurrent protection as indicated on the drawings.

B. The disconnect shall be a fused load break switch.

C. A quantity of (3) current limiting power fuses shall provide the overcurrent protection.

D. Units shall be provided in two high construction for units rated 400 Amps and below.

E. The feeder disconnect unit shall consist of three isolated compartments.
   1. Power Bus Compartment
   2. Power Cell
   3. Low Voltage Panel
   4. The functional compartment specifications shall follow the motor specification where applicable.

F. Provide (3) load cable terminals

2.6 SMC UNIT DESIGN

A. The controller shall be manufactured by a single vendor. The medium voltage, solid-state controller shall be mounted in the MCC lineup as described herein..

B. The controller shall be of modular design to provide for ease and speed of maintenance. The modules are to be manufactured by one supplier, designed to allow ease of maintenance, including removal of medium voltage components and power electronic components.

C. The structure shall be divided into isolated compartments as follows:
   1. Main power bus and ground bus compartment
   2. Power cell compartment
   3. Low voltage compartment

D. Metal or glass polyester barriers shall be provided between the low voltage compartment and the power cell and/or main power bus compartment, and between the power cell and main power bus compartment. Personnel shall have access to the low voltage compartment, with the controller energized, without being exposed to any medium voltage.

E. Vacuum Contactor Specifications (Input And Bypass)
   1. The electrically held medium voltage contactor shall be the Allen-Bradley model 1502 vacuum type or equivalent
   2. The following current ratings shall be available:
      a. 400 A

b. 800 A

3. The contactor shall have visual contact wear indicators. No special tools are required for checking contact wear.
4. Vacuum bottle and coil maintenance shall be performed on the contactor while it is mounted. Removal of contactor is not required.

F. Isolation Vacuum Contactor
1. The vacuum input contactor shall be fixed mounted inside the power cell. Fixed mounting provides solid, continuous contact, lowering maintenance requirements considerably. The contactor shall be interlocked with the non-load-break isolating switch, both electrically and mechanically, which shall provide the following safety features:
   a. Prevent the isolating switch from being opened or closed when the contactor is in the closed position.
   b. Prevent the opening of the medium voltage door when the isolating switch is in the closed position.
   c. Prevent the closing of the isolating switch when the medium voltage door of the controller is open.
   d. Remove control power from the control power transformer (CPT), power transformers (PTs) or external power source to the control circuit when the isolating switch and contactor are in the open position.

G. Bypass Vacuum Contactor
1. A contactor shall be provided to bypass the SCRs once the motor is up to full speed. When a stop option is selected, the bypass contactor will open, bringing the SCRs back into the power circuit. It shall be fixed mounted in the main power cell.
2. The bypass contactor shall be capable of providing a full voltage start in case of emergency bypass.

H. Control Wire Specification
1. The control wire shall be an insulated (with a flame retarding thermoplastic compound), flexible stranded, tinned copper wire supported and neatly bundled. Red wire shall indicate AC power, blue wire shall indicate DC power and green wire shall indicate ground. Other colors or combinations may be used for specific applications. The control wire shall be isolated from high voltage components in the power cell (whenever possible), and wire tube markers which are numbered according to the electrical diagram, shall be provided at each end of the wire.
2. All of the control wire terminations shall be a screw-type, copper-compression-type terminal block or connector which firmly grips the conductor. Non-insulated, locking-type, fork tongue lugs shall be provided on the control wire terminating on the control power transformer(s) and current transformers.

I. LOW VOLTAGE CONTROL PANEL

1. Each controller shall have a separate, front accessible, low voltage control compartment. The compartment shall be completely isolated, using metal barriers between the low voltage compartment and the power cell and/or main power bus compartments for utmost safety.
   Optional meters, motor protection relays, selector switches, operators, indicating lights, etc., shall be mounted on the front of the low voltage control panel, and arranged in a logical and symmetrical manner. The low voltage panel shall provide the following features:
   a. Space shall be provided for low voltage control devices, transducers and metering.
   b. There shall be necessary terminal blocks supplied. Extra terminal blocks can be supplied as an option.
   c. There shall be low voltage control panel access without turning the controller "OFF" when opening the low voltage control panel door.
   d. All remote low voltage cables shall be able to enter from the top or bottom of the structure. Access to the wireways shall be by means of removable entry plates on the top and bottom of the structure.
   e. As standard, the combination controllers shall incorporate a swing-out low voltage panel which provides easier access to the power cell to make bus splicing and load cable connections. All products shall have a swing-out low voltage panel, which is interlocked with the power cell compartment (the panel shall not have the ability to swing open until the power cell is "OFF" and isolated from the main power bus) to allow easy access to medium voltage equipment, i.e. power stacks, power bus, power factor correction capacitor, or other similar equipment.
   f. Pilot control relays shall be used to operate and economize the vacuum contactor.
   g. The control panel supply voltage shall be 120 V AC, 50/60 Hz. It shall be rectified to provide a DC operating voltage for the vacuum contactor coils and economizing relay.
   h. There shall be a two-pole, three-conductor (with a grounding prong) male plug to provide a means for connecting a two-pole, three-conductor receptacle from a remote 120 V AC, 50/60 Hz supply to operate the control circuit when it is in the TEST position (combination controllers only).
   i. The low voltage control panel door shall have a viewing window, allowing the user to monitor the MV SMC-Flex controller operation via the built-in display.

J. INTERLOCKING
   1. Mechanical interlocking, including cable interlocks, horizontal and vertical ram interlocks, shall be provided to prevent the opening of any power cell door or medium voltage compartment until the non-load-break isolating switch is fully in the open position and power is removed (the external operating handle must be in the OFF position).

2. Optional key interlocks configured to operate with the operating handle or power cell door shall be available when interlocking is required with another specified device, i.e. main breaker, load-break switch, starter, etc.

K. POWER FUSES AND FUSE HOLDERS
1. R-rated current limiting power fuses shall be provided. R-rated fuses shall be used for the short circuit protection of medium voltage motors and motor controllers.
2. The medium voltage product shall have fixed power fuse holders that are separately mounted in the power cell, not on the contactor, and be located to allow easy inspection and replacement without any disassembly. The power fuses shall have a spring actuated blown fuse indicator. The power fuse size shall be selected when motor data and the protective device characteristics are known.

L. CONTROL POWER TRANSFORMER
1. The control power shall be 110/120 V AC, and shall be obtained from a control power transformer (CPT) located in each controller power cell, or from a separate control source. The dry-type CPT shall be sized as required for the control system load, plus 350 VA extra capacity for the customer's use when the standard control circuit is supplied and shall have primary and secondary fuses.
2. The secondary circuit of the transformer(s) shall be disconnected from the control circuit by means of the isolating switch auxiliary contacts. This is to prevent backfeeding through the transformer(s) and to isolate the power cell when the control circuit is in the TEST mode.
3. The standard control power transformers used in the controller shall be a compensated type with an output accuracy of approximately 4% over nominal at no load. They shall be designed to maintain voltage at in-rushes of up to 600%, which results in a 2% overvoltage at full load.

M. PRIMARY FUSES
1. The primary side of the control power transformers and/or potential transformers shall be protected by current limiting fuses sized according to requirements. The interrupting rating of the primary fuses shall be 50 kA symmetrical.

N. SECONDARY FUSES
1. The secondary side of the control power transformer and/or potential transformers shall be fused appropriately to protect the transformer(s) from overloads. The standard control circuit shall have one leg of the secondary grounded.

O. CURRENT TRANSFORMERS
1. The medium voltage power cell shall include three (3) current transformers of sufficient VA capacity to meet the requirements of all the devices

connected to them.

2. Each current transformer shall have the primary rating sized appropriately in relation to the full load current rating of the motor or feeder. The secondary of the current transformers shall have a five (5) amp output and an accuracy suitable for the type and quantity of protection or metering devices connected to it. All current transformer control wiring shall be terminated on the current transformer with locking type, fork tongue lugs.
3. An appropriate load termination location shall be provided to accommodate lugs with single or two-hole mounting, for connection of the load cables, when either bar or donut type current transformers are supplied.
4. The power cell shall have provisions to locate a toroid (donut) style, ground fault sensing current transformer, when the zero sequence ground fault protection feature is required (Combination Controller only).

P. CONTROL MODULE • LOGIC DESIGN FEATURES

1. Mechanical
   a. The control module shall be designed for mounting within the low voltage panel (for safety reasons) and shall be compatible with the full range of current and voltage ratings.
   b. The control module shall consist of a power supply, logic control circuitry, silicon controlled rectifier (SCR) firing circuitry, I/O circuitry, a digital programming keypad, a backlit LCD display, and a serial communication port.
2. Programming and Display
   a. Digital parameter adjustment shall be provided through a standard built-inkeypad. Analog potentiometer adjustments are not acceptable. A built-in backlit LCD display shall be provided for controller set-up, diagnostics, status, and monitoring. The display shall be three-line, 16-characters minimum.
   b. The display shall be capable of depicting alphanumeric characters in any of the following languages, by adjustment of a single parameter:
      1) English
      2) French
      3) Spanish
      4) German
      5) Portuguese
      6) Mandarin
3. Communications
   a. A serial communications port DPI (Drive Programming Interface), shall be provided as standard. Optional communications protocol interface modules shall be available for connection to Remote I/O, DeviceNet™, ControlNet™, Ethernet, RS-485, and Profibus-DP.
4. Electrical
   a. The control module shall provide closed-loop digital microprocessor control and supervision of all controller operations, including SCR

pulse firing control. The control module shall be the same as used for the SMC-Flex low voltage product family.

5. SMC-Flex Control Modes
   a. The control module shall offer the following functions:
      1) Soft Start -with Selectable Kickstart
      2) Soft Stop
      3) Current Limit Start -with Selectable Kickstart
      4) Dual Ramp -with Selectable Kickstart
      5) Full Voltage
      6) Preset Slow Speed
   b. Pump Control
      1) The Pump Control option shall be implemented to provide closed loop control of a motor to match the specific torque requirements of centrifugal pumps for both starting and stopping. This shall aid in eliminating the phenomena commonly referred to as "water hammer". Methods utilizing Soft Start and Soft Stop shall not be acceptable.
      2) Closed loop control shall be achieved without using external sensors or feedback devices.
      3) The Pump Start time shall be user adjustable from 0 to 30 seconds.
      4) Pump Stop shall be initiated by a dedicated Pump Stop input. A coast-to-rest stop shall still be possible with a separate stop input.
      5) The Pump Stop time shall be user adjustable from 0 to 30 seconds.
      6) Extended Pump Start or Stop times may be made available, upon consultation with qualified factory personnel.
      7) Kick-start shall provide an adjustable time pulse of current prior to the normal start mode. The current shall be controlled to provide 0-90 % of locked rotor torque for a time between 0.0 and 2.0 seconds. This feature shall be field selectable.
6. SMC-Flex Monitoring
   a. The controller shall provide the following monitoring functions indicated though the built-in LCD display; or remotely via the communication port:
      1) Phase-to-phase supply voltage
      2) Three-phase line current
      3) Three-phase power (MW, MWh, power factor)
      4) Elapsed time
      5) Motor thermal capacity usage
      6) Motor speed (with optional use of tachometer input)
7. SMC-Flex Protection and Diagnostics
   a. The following protection and diagnostics shall be provided as standard with the controller:
      1) Power loss (with phase indication; pre-start)
      2) Line fault (with phase indication; pre-start) advising: –Shorted SCR
      3) Missing load connection

4) Line fault (running protection) advising: –Power loss –Shorted SCR
5) Voltage unbalance *
6) Phase reversal *
7) Undervoltage *
8) Overvoltage *
9) Stall *
10) Jam *
11) Overload *
12) Underload *
13) Excessive starts/hour *
14) Open gate (with phase indication)
15) Overtemperature (power stack, with phase indication)
16) Communication loss
17) Motor temperature (via PTC input)

* These protective features shall be selectable.

b. Overload Protection shall include:
1) The control module shall meet applicable standards as a motor overload protective device
2) Three-phase current sensing shall be utilized; the use of two current transformers shall be unacceptable.
3) Overload trip classes of 10, 15, 20 and 30 shall be provided and user-programmable.
4) Electronic thermal memory shall be provided for enhanced motor protection
5) Protection shall be available through the controller while in bypass configuration
6) Separate overload relay shall be provided for emergency bypass operation

Q. SCR POWER CIRCUIT DESIGN
1. The SCRs shall be protected from voltage transients with an R-C snubber network to prevent false SCR firing.
2. The SCRs shall be protected from overvoltage with voltage threshold gating circuitry.
3. The SCR firing circuitry shall be fully isolated from the control circuits. Fiber optic cables shall be used for isolation from the logic circuits.
4. Current loop gate driver boards shall be utilized to increase efficiency of the controller, reducing power consumption and heat.

2.9 UNIT MODIFICATIONS

A. Motor Run Time Meter
1. Provide a digital, non-resettable, door-mounted elapsed time meter.
2. The meter shall have six digits with tenths.
3. The meter shall be electrically interlocked with the contactor to indicate actual motor operating hours.

B. Low Voltage Surge Suppressors
   1. Provide low voltage surge suppressors across each 120 V coil in the control circuit.

C. Metering
   1. Main Switch or Incoming Section
      a. Provide a digital metering system.
      b. The metering system shall consist of a monitoring unit and display module. The unit shall be shipped with the necessary current transformers and potential transformers.
      c. Monitoring Unit
         1) The monitoring unit shall Rockwell Automation Allen-Bradley Powermonitor 3000.
         2) The monitor shall have the following metering capability
            a) Phase current (A-B-C) with plus or minus 0.2 percent accuracy
            b) Average three phase current and neutral current with plus or minus 0.2 percent accuracy
            c) Phase to phase and phase to neutral voltages with plus or minus 0.2 percent accuracy
            d) Current and voltage unbalance
            e) Power functions kW, kVA and kVAR with plus or minus 0.4 percent accuracy
            f) Demand functions kW and kVA with plus or minus 0.4 percent accuracy
            g) Energy functions kWH and kVAH with plus or minus 0.4 percent accuracy
            h) Power factor with plus or minus 0.4 percent accuracy
            i) Frequency with plus or minus 0.05 percent accuracy
            j) Distortion analysis with THD, Crest Factor (I, V) and Distortion Power Factor.
            k) Maximum metering update rate of 50ms.
         3) The monitor shall have a control relay output.
         4) The monitor shall be ANSI/IEEE tested to meet or exceed the Surge Withstand Capability (SWC) C37.90.1 – 1989 for protective relays and relay systems on all power connection circuit terminations.
      d. Display Module
         1) The display module shall be as manufactured by Rockwell Automation Allen-Bradley
         2) The display module shall have a highly visible LED display.
         3) The display shall be five inches square and designed to fit into a circular cut-out that is four inches in diameter.
         4) The display shall be utilized for viewing data and for programming of the monitoring unit.
      e. Potential Transformers

a) A common set of two (2) PT's can provide voltage reference for one MCC line-up.

2. Controllers
   a. Provide switchboard type (4 ½ inch) metering.
   b. Provide analog ammeter with ammeter switch.
   c. Provide analog voltmeter with voltmeter switch.
   d. Provide (3) current transformers.
   e. Provide (2) potential transformers with primary and secondary fusing.
3. Feeder Units
   a. Provide switchboard type (4 ½ inch) metering.
   b. Provide analog ammeter with ammeter switch.
   c. Provide analog voltmeter with voltmeter switch.
   d. Provide (3) current transformers.
   e. Provide (1) potential transformer with primary and secondary fusing.

D. Pilot Devices
   1. Pilot devices shall be Allen-Bradley Bulletin 800H (NEMA Type 4/4X/13) and shall be mounted on the enclosure door.
   2. For motor starter provide pilot lights, mounted on the enclosure door, for indication of ON, OFF and OVERLOAD. Pilot lights shall be transformer type.

E. Terminal Blocks
   1. Provide ten additional unwired terminal blocks in each unit.
   2. Must be Allen-Bradley type 1492.

F. Auxiliary Relays
   1. Provide auxiliary control relays as indicated on the drawings.
   2. The relays shall be Allen-Bradley 700P or 700CF relays.

G. Power Factor Correction Capacitors
   1. Power factor correction capacitors shall be provided for each controller in the MCC, sized to correct the power factor to 0.95%.
   2. Contactors shall be provided ahead of the capacitors, and interlocked with the shorting contactor, to prevent energizing until the controller has completed the ramping sequence and the shorting contactor is closed.
   3. The capacitors shall be furnished with fusing and overload protection.
   4. Provide cooling fans as required.

2.10 MOTOR PROTECTIVE RELAY

A. The motor management relay shall provide primary protection and management to medium voltage motors. The relay shall be equipped with the following protection functions.
   1. Motor Thermal Overload Model (49)

a. Include 15 standard overload curves, a custom curve feature, and a curve specifically designed for the starting of high inertia loads, when the acceleration time exceeds the safe stall time.
b. The stator protective thermal model shall combine inputs from phase and unbalance currents, and RTD winding feedback. This will then cause the model to become dynamic in nature in order to follow the loading and temperature of the motor.
c. Motor cooling time constants
d. Rotor protection during stall and acceleration. To achieve this a speed switch input shall be available.

2. The relay shall detect ground faults or earth leakage currents as low as 0.25 A using a 50:0.025 Ground CT.
3. Use phase and unbalance current heating to calculate motor thermal capacity during starting and running states
4. Settable motor stopped and motor running cooling time constants
5. Phase and residual overcurrent elements (50P/50G)
6. Unbalance / single phase biasing (46)
7. Load-loss (undercurrent) (37)
8. Mechanical jam (48)
9. Motor stall protection
10. Re-start blocking timer to be used as a start permissive to ensure the motor had slowed to a safe speed or to a complete stop, before it can be re-started again
11. Antibackspin protection ensuring that the motor can only be re-started when it has slowed to within acceptable limits. A backspin detection voltage input shall be provided to measure frequency. If the measured frequency is below a programmed minimum threshold, the backspin start inhibit shall be removed
12. Starts-per-hour (66)
13. Minimum-time-between-starts
14. The relay shall provide an option for voltage transformer inputs, which shall be used to provide overvoltage (59), undervoltage (27), voltage phase reversal (47), overfrequency (81O) and underfrequency (81U) functions
15. The relay shall be equipped with an Undervoltage Auto-restart function that will restart the motor after an undervoltage trip caused by a momentary loss of power.
16. 12 RTD inputs with associated over-temperature protection functions including alarm and trip settings, with corresponding settable time delays, and associated outputs. The following additional functionality shall be provided, associated to RTDs:
    a. Able to configure each of the twelve RTDs as “None” or any one of four application types: “Stator”, “Bearing”, “Ambient”, or “Other”
    b. RTD type shall be selectable between four different RTD types: “100 Ohm Platinum”, “120 Ohm Nickel”, “100 Ohm Nickel”, or “10 Ohm Copper”

c. The motor relay shall incorporate the RTD inputs to support the following:
d. Thermal overload model biasing
e. Temperature alarms and trips (49/38)
f. RTD open- or short-circuit alarm
g. The motor relay shall include trip voting for extra reliability in the event of RTD malfunction. If enabled, a second RTD must also exceed the trip temperature of the RTD being checked before a trip is issued
h. Provisions shall be included to allow the RTDs to be identified by name

17. The relay shall be able to monitor up to four remote RTD modules, each with 12 RTD inputs, with associated over-temperature protection functions including alarm and trip settings, settable time delays, and associated outputs. Additional functionality shall be identical to that provided by the on board RTDs as describer above.
18. Protection functions associated to Power, which include alarm and trip settings, with corresponding settable time delays, and associated outputs:
    a. Power Factor (55)
    b. Reactive Power
    c. Under Power (37)
    d. Reverse Power

B. The relay shall operate with either wye-connected (four wire) or open-delta-connected (three wire) potential transformers, and three phase, four wire connected current transformers.

C. The relay shall include provisions to allow its use in conjunction with variable frequency drives. All of the elements shall function properly with the exceptions of voltage and power elements.

D. The motor protection relay shall have five (5) output relays, and six (6) digital inputs. The output relays shall be as follows: Trip Relay, Alarm Relay, two auxiliary relays, and a service relay. Five of the six digital inputs shall have the following pre-assigned default functions:
    1. Access Switch to allow changing of any setpoint values from the face plate,
    2. Differential Switch to accept inputs from an external differential protection relay
    3. Emergency Restart to allow a hot motor to be restarted
    4. External Reset, to allow resetting trips or latched alarms
    5. Speed Switch to accept a trip signal from a speed monitoring device

E. Although assigned default functions, these five inputs, along with the one remaining spare input, can be user programmable to alternate functions. The function that the input is used for may be chosen from the following list of

functions: Starter Status configured for either an 'a' or 'b' auxiliary contact, Waveform Capture, Digital Counter, DeviceNet Control, and General Switch functions in which an alarm and/or trip may then be configured for that input. The relay shall be able to monitor the digital inputs of up to four remote RTD modules.

F. The relay shall allow motor starting and stopping via any of the communication ports. When a Stop command is sent the TRIP relay shall be activated for 1 second to complete stop sequence. When a Start command is issued, an output relay shall be assigned for starting control, which shall be activated for 1 second to complete the start sequence. The Serial Communication Control function shall also be used to reset the relay and activate a waveform capture.

G. The relay shall be capable of protecting the motor during the entire starting process in Reduce Voltage starting applications.

H. The relay shall provide complete monitoring and metering functions. These shall include:
   1. Current: Phasors, RMS Values of per Phase, Average, Motor Load, Current Unbalance, Unbalance Biased Motor Load, Ground, Differential Currents
   2. Voltage: Phasors, RMS Values of Phase-Phase and Phase-Neutral, Average Voltage
   3. Frequency
   4. Temperature of each RTD Inputs
   5. Motor Speed (RPM)
   6. Power: Power Factor, Three phase Real (kw, hp), Reactive (kvar), Apparent (kva) Power
   7. Energy: Watt-hours, Var-hours
   8. Demand: Rolling Demand method, time interval, programmed to 5 to 90 min in steps of 1 minute
   9. An event recorder with a record of the last 512 events, time tagged with a resolution of 10 ms.
   10. The waveform capture feature is similar to a transient/fault recorder. The relay shall storage of up to 16 cycles of data, captured for Phase A, B, and C currents (Ia, Ib, and Ic), Ground currents (Ig), Phase A-N, B-N, and C-N voltages (Van, Vbn, and Vcn) for wye connections, Phase A-B and B-C (Vab and Vbc) for open-delta connections
   11. The relay shall be able to provide data in the form of trending or data logger, sampling and recording up to eight actual values at an interval defined by the user. Several parameters shall be trended and graphed at sampling periods ranging from 1 second up to 1 hour. The parameters which can be trended by the Setup software shall be: Phase Currents A, B, and C, and Average Phase Current, Motor Load, Current Unbalance, Ground Current, System Frequency, Voltages Vab, Vbc, Vca Van, Vbn & Vcn, Power Factor, Real (kW or hp) Reactive (kvar), and Apparent (kVA)

Power, Positive Watt-hours, Positive and Negative Var-hours, Hottest Stator RTD, Thermal Capacity Used, RTDs 1 through 12 temperature, Remote RTDs 1 through 12.

12. The relay shall include four transducer outputs with a settable DC output range of 0 to 20 mA, 4 to 20 mA or 0 to 1 mA, which may be assigned to any measured parameter. The range of these outputs shall be scalable.
13. The relay shall be able to monitor up to four remote RTD modules, each with four Analogue Outputs, with settable DC output range and functionality identical to the on board Analogue Outputs. The remote RTD Module Analogue Outputs shall be assigned to any temperature measured by the module RTDs.
14. Latest trip report containing date and time, cause, phase, ground, motor load, current unbalance, Line-Line and Line-ground voltages, hottest stator RTD, system frequency, real, reactive and apparent power, and power factor
15. Alarm status information reflecting Alarm Name as programmed and status.
16. Start block timer status including overload lockout, start inhibit, starts per hour, time between starts, and restart block

I. The Motor Learned Data shall capture up to 250 sets of motor starting values, averaged over up to five motor starts. The motor learned data must be graphically represented through a PDF report. The following is the learned data captured and stored and can also be printed and filed.
   1. Learned Acceleration Time
   2. Learned Starting Time
   3. Learned Starting Capacity
   4. Learned Running and Cool Time Constant
   5. Learned Stopped Cool Time Constant
   6. Learned Unbalance K Factor
   7. Learned Average Motor Load
   8. Learned Run Time After Start
   9. Date of last learned Date average calculation or last record

J. The relay must provide a high-speed data logger to capture analog signals during motor starting conditions. A total of six individual logs (1 baseline and rolling buffer of last 5 starts), each 30 seconds long are available to record key analog quantities at a sampling rate of 200 milliseconds. The following information shall be captured.

   1. General:
      a. True RMS Phase A, B and C Currents
      b. Phase Current Unbalance
      c. True RMS Ground Current
      d. True Phase to Phase or Phase to Ground Voltages
      e. Thermal Capacity Accumulated (%)

f. System Frequency
g. Breaker / Contactor Status

2. Preventive Maintenance Information:
   a. The relay shall keep count of number of trips by type
   b. Number of motor starts or start attempts
   c. Number of Emergency Restarts
   d. Motor running hours
   e. Autorestart start attempts
   f. Time to autorestart
   g. Digital input counters

K. The relay shall have starter failure detection feature which shall produce an alarm in the event that the motor relay does not detect a starter/breaker open condition after a trip is initiated.

L. The relay shall have the capability to display up to 5 user programmable text messages.

M. Under normal conditions, if no front panel activity is detected within a settable time, the screen shall sequentially display up to 30 default messages. Any actual value or setpoint message shall be selectable for default display.

N. Security / Change History Report

The relay must comply with NERC CIP security reporting requirements and provide traceability. The relay must maintain a history of the last changes made to the configuration, including modifications to settings and firmware upgrades. A summary history of the last ten sessions and a list the last 100 specific setting changes made must be recorded and stored in non-volatile memory. The report must be available to be saved and printed in PDF format.

1. Security Setting Reports shall include the following information:
2. Dates and times of security setting changes
3. MAC address of user making setting changes
4. Listing of modified changes
5. How setting changes were made (Keypad, Front serial port, Ethernet)

O. User interfaces shall include:
   1. A 40 character LCD display, and navigation keys
   2. Indicator LEDs on the front panel which shall provide a quick visual indication of status
   3. A front panel RS232 serial port that shall provide easy computer access. The communications protocol shall be Modbus RTU
   4. Two rear RS485 ports. The communications protocol shall be Modbus RTU

5. An RS485 communications port shall be provided specifically designed to communicate to Remote RTD modules. The relay shall be capable of communicating with up to four Remote RTD modules. Access to the remote RTD modules for setpoints and actual values shall be achieved through the motor relay via any of the available communication ports. The remote RTD communication port standard media shall be a three terminal port. Optional media shall be fiber optic, with a maximum baud rate of 19.2 kBs, fiber sizes 50/125, 62.5/125, 100/140, and 200 µm, and emitter fiber type 820 nm LED, multimode.
6. An optional RJ45 Ethernet port shall be provided to allow 10BaseT Ethernet connectivity to Local or Wide Area Networks. The communications protocol shall be Modbus TCP
7. An optional terminal port shall be provided to allow DeviceNet or Profibus connectivity to Local DeviceNet or Profibus Networks.
8. The relay shall be capable of being set by Windows-based, Easy to use, Setup graphical terminal interface
9. To make the data acquisition more efficient, the motor relay shall provide a User Definable Memory Map, which shall allow a remote computer to read up to 125 nonconsecutive data registers by using one Modbus packet. The User Definable Memory Map shall be programmed to join any memory map address to one in the block of consecutive User Map locations, so that they can be accessed by means of these consecutive locations. The User Definable area shall have two sections:
    a. A Register Index area containing 125 Actual Values or Setpoints registers
    b. A Register area containing the data located at the addresses in the Register Index

P. A testing feature shall be included to allow testing analogue outputs and relays, without the need for external voltage and current inputs.

Q. The relay shall be capable of being programmed through a windows based software program that is capable of the following:

1. The software program will operate in the following fashion
    a. Request system and motor nameplate data from user through display screens.
    b. Generate cautionary notes based on inputted information
    c. Generate settings file
    d. Review settings with user with the option to disable any configured settings that are not required
    e. Provide PDF report outlining the settings that have been generated, as well as any cautionary notes required
    f. Report and Settings file to be saved in user-selectable location
2. The following system and protection settings will be generated based on inputted information

a. All CT, VT and Power System settings
b. All Thermal Model settings including
    1) Short Circuit
    2) Mechanical Jam
    3) Unbalance
    4) Undercurrent
    5) Ground Fault
c. All Motor Start / Inhibit protections
d. Local RTD configuration, alarming and tripping
e. Under / Over Voltage
f. Under / Over frequency
g. Phase Reversal
h. Local Digital input for 52A / B contact
i. All other settings will have default values

3. Include Typical Wiring Diagram based on CT / VT type
4. Provide a summary of all enabled settings in a PDF format that can be saved or printed.

R. Motor Health Report

The Motor Health Report included with the relay will provide a detailed history of the operation and performance of the associated motor in both graphical and data format. The following information will be provided in the Motor Health Report. The report can either be saved to a location in a soft copy or be printed in PDF format.

The report shall be divided into seven categories and provide the following information:

1. Device Summary
    a. Requested Period
    b. Report Created By
    c. Motor Name
    d. Protection Device
    e. Firmware Version
    f. Motor FLA
    g. Rated Voltage
    h. Phase Rotation
    i. System Frequency
    j. Motor Running Time
2. Status Overview
    a. Provide historical learned date of the following
    b. Acceleration Time
    c. Starting Current
    d. Starting Capacity
    e. Motor Load
    f. Run Time After Start

3. Trip Summary
    a. Overload / Thermal
    b. Current
    c. Voltage / Frequency / Power
    d. Miscellaneous
    e. Information shall be represented both graphically and numerically
4. Motor Operating History
    a. The Motor Operating History will provide information extracted from the Events Record
    b. Motor Start / Running
    c. Manual Stop Command
    d. Trip Command
    e. Lockout
    f. Alarm Conditions
    g. Emergency Restarts
    h. Information shall be represented both graphically and numerically
5. Motor Starting Learned Information
    a. Learned Data will be captured for every motor start
    b. 250 Learned Data Records will be stored in the relay
    c. Learned Acceleration Time
    d. Learned Starting Current
    e. Learned Starting Capacity
    f. Learned Average Motor Load
    g. Learned Average Run Time After Start
    h. Information shall be represented both graphically and numerically
6. Motor Start Data Logger
    a. The Motor Start Data Logger consists of Baseline Record and 5 additional records
    b. Each record shall contain 6 channels of information
    c. Each channel shall contain 150 samples, sampled at 200ms intervals for a total of 30 seconds
    d. Information to be included in the Motor Start Data Logger:
    e. Average Current
    f. Average Current Unbalance in Percent
    g. Ground Current
    h. Average Voltage
    i. Thermal Capacity Used
    j. Frequency
    k. Breaker Status
    l. Information shall be represented both graphically and numerically
7. Motor Stopping / Tripping
    a. Events that are related to the stopping or tripping of the motor
    b. Overload Trip
    c. Mechanical Jam
    d. Short Circuit
    e. Under Power

f. Current Unbalance
g. RTD Temperature
h. Ground Fault
i. Under/Over Voltage
j. Under/Over Frequency
k. Manual/Remote Stop
l. Information shall be represented both graphically and numerically

S. To help extend product life, and to protect the motor protection relay from hostile and harsh environments including moisture, temperature variations, salt spray, organic attack (fungus), and aggressive chemicals and vapors, the product manufacturer shall provide optional harsh environment conformal coating.

T. The motor protective relay shall be the Multilin 369, or equal.

PART 3 – EXECUTION

3.1 MANUFACTURE TESTING AND INSPECTION

A. Standard Testing
1. The following tests shall be carried out in accordance with applicable requirements and/or specifications of Canadian Standards Association (CSA), Underwriters Laboratories (UL), National Electrical Manufacturers Association (NEMA), European Standard (EN), and International Electrotechnical Commission (IEC).
2. Functional checks shall be performed wherever possible; otherwise, inspection and continuity checks shall be made.
3. A "HI-POT" dielectric withstand test shall be performed on all buswork and cables from phase-to-phase and phase-to-ground (except solid-state components, low voltage controls and instrument transformers). The voltage level used for this test depends on the product's nominal AC voltage.
4. Component devices shall be functionally operated in circuits as shown on electrical diagrams or as called for by specific test instructions.
5. Instruments, meters, protective devices and associated controls shall be functionally tested by applying the specified control signals, current and/or voltages.
6. Medium Voltage starters shall be inspected for the following:
   a. Electrical interlocking
   b. Motor protection and ground fault if applicable

B. Physical Inspection
1. The product must meet all applicable engineering and workmanship standards and specifications. All components shall be verified against engineering documentation to be present and correctly installed.

2. All bus and bus connections shall be checked for proper clearance, creepage, phasing, and torque.
3. Warning plates, isolation barriers, and mechanical interlocks must provide sufficient safety/isolation for personnel and equipment.
    a. Warning labels and nameplates must be present and in their specified positions to advise personnel of possible hazards.
    b. Isolation barriers must be in place within the cabinet. Such barriers protect personnel from touching live medium voltage components in an area that otherwise does not have power supplied to it.
    c. Operation of isolation switch handle and door interlocks must be verified. The interlocking prevents the opening of any medium voltage door on a medium voltage cabinet when the isolation switch handle has been moved to the full ON position.

3.2 MANUFACTURE'S FIELD SERVICES

A. The service division of the controller manufacturer shall perform all start-up services. The use of third party supplier start-up personnel is not allowed.

B. Start-up personnel shall be direct employees of the controller manufacturer.

C. At a minimum, the start-up service shall include:
    1. Pre-Installation Meeting
        a. The start-up plan
        b. The start-up schedule
        c. Installation requirements
    2. Pre-Power Check
        a. Inspect the starter's mechanical and electrical devices enclosed
        b. Perform a tug test on all internal connections within the starter and verify wiring.
        c. Verify critical mechanical connections for proper torque requirements.
        d. Verify and adjust mechanical interlocks for permanent location.
        e. Confirm all sectional wiring is connected properly.
        f. Re-verify control wiring from any external control devices.
        g. Set up auxiliary equipment with customer supplied parameters.
        h. Confirm cabling of starter to motor and line feed.
        i. Megger Motor Resistances.
    3. Power-up and Commissioning
        a. Apply medium voltage to the starter and perform operational checks.
        b. Exercise the starter in Test Mode (combination controllers).
        c. Run the starter motor system throughout the operational range to verify proper performance.
    4. Record of all measurements

3.3 TRAINING

A. An authorized factory representative shall provide training in accordance with Section 16050.

B. The manufacturer shall outline the training session duration and content.

C. The basis of the training shall be the controller, the engineered drawings and the user manual.

D. The instruction shall include the operational and maintenance requirements of the controller.

E. At a minimum, the training shall:
   1. Review of the engineered drawings identifying the components shown on the drawings.
   2. Review starting / stopping options for the starter.
   3. Review starter and contactor hardware.
   4. Review the maintenance requirements of the controller.
      a. Hardware replacement procedures
      b. Power device replacement procedures
      c. Fault analysis and troubleshooting
      d. Preventative maintenance procedures
   5. Review safety concerns with operating the controller.

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SECTION 16370

OVERHEAD HIGH VOLTAGE POWER DISTRIBUTION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This specification covers the requirements for aerial electrical transmission and distribution systems.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. See Electrical Section 16050, Basic Electrical Materials & Methods for general requirements relating to electrical work performed under this Contract.

B. See Electrical Section 16271, Liquid Filled Substation Transformers for requirements relating to electrical work associated with substation transformers.

C. See Electrical Section 16312, Medium Voltage Power Distribution.

D. See Electrical Section 16315, Primary Grounding for grounding of aerial electrical distribution systems.

1.3 SUBMITTALS

A. Catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents shall be submitted.

B. A complete itemized listing of equipment and materials proposed for incorporation into the work shall be submitted. Each entry shall include the item number, the quantity of items proposed, and the name of the manufacturer of the item.

C. Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams and other information necessary to define the installation and enable the A/E to check conformity with the requirements of the Contract Drawings shall be submitted. Detail drawings shall as a minimum include:
   1. Dead-end structures and components.
   2. Calculations for steel poles and foundations.
   3. Pole top switches.
   4. Conductors.
   5. Insulators.

6. Surge arrestors.

If departures from the Contract Drawings are deemed necessary by the Contractor, complete details of such departures shall be submitted with the detail drawings. Accepted departures shall be made at no additional cost to the Owner.

D. Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Detail drawings shall consist of the following:
   1. Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded.
   2. Drawings shall include anchor bolt details and patterns, assembly and erection details, and structural members, connections, and equipment mounting details.
   3. Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

E. Design calculations for dead-end structures. The calculations shall show all conductor loading, accounting for ice and wind and deflection. Calculations shall also include static loading and seismic criteria. Calculations shall be based on the following information:
   1. 10,000 lb NESC heaving loading per phase and static
   2. Conductor size of 477 ACSR
   3. Shield wire size #1/0 ACSR
   3. Horizontal line angle of 25 degrees
   4. Deflection not to exceed 6 inches at 60 degree F

F. A proposed field test plan shall be submitted 30 days prior to testing the installed system. No field test shall be performed until the test plan is accepted. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits. 6 copies of the information described below in 8-1/2" x 11" binders having a minimum of 5 rings, and including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.
   1. A list of equipment used, with calibration certifications.
   2. A copy of measurements taken.
   3. The dates of testing.
   4. The equipment and values to be verified.
   5. The condition specified for the test.

6. The test results, signed and dated.
7. A description of adjustments made.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.5 EXTRA MATERIALS

A. One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the Owner when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Dead-end and take-off structures shall be Valmont, or equal.

B. High voltage switches shall be as manufactured by S&C, or equal.

C. Surge arrestors shall be as manufactured by ABB, or equal.

2.2 GENERAL REQUIREMENTS

A. Products shall conform to the following requirements. Items of the same classification shall be identical, including equipment, assemblies, parts, and components.

2.3 STANDARD PRODUCT

A. Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.4 NAMEPLATES

A. General
   1. Each major component shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Equipment containing liquid-dielectrics shall have the type of dielectric on the nameplate. Nameplates shall be made of non-corrosive metal. As a minimum, nameplates shall be provided for circuit breakers, capacitors, meters and switches.

2.5 CORROSION PROTECTION

A. Aluminum Materials
   1. Aluminum shall not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL Standards shall be used.

B. Ferrous Metal Materials
   1. Hardware
      Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM Standards.
   2. Equipment
      Equipment and component items which are not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM Standards without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16 inch from the test mark. Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.
   3. Structures
      Preparation and fabrication for galvanized structures shall be in accordance with ASTM A-385. Galvanized members shall meet ASTM A-123. Safeguards against embrittlement shall be in accordance with ASTM A-143. Galvalnized coating thickness shall be measured using ASTM E-376 for Magnetic Coating Thickness Gauge.
   4. Finishing
      Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be field painted as specified in Division 9.

2.6 CONDUCTORS, CONNECTORS, AND SPLICES

A. Aluminum-Composition Conductors
   1. Aluminum-conductor-steel-reinforced, ACSR, shall comply with ASTM Standards.

B. Connectors and Splices
   1. Connectors and splices shall be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors.

2.7 HIGH-VOLTAGE LINES

A. Bare High-Voltage Lines

   1. Bare medium-voltage line conductors shall be aluminum-conductor-steel-reinforced, ASCR. Conductor types shall not be mixed on any project, unless specifically indicated. Conductors larger than No. 2 AWG shall be stranded.

2.8 POLES, STRUCTURES, AND HARDWARE

A. Poles shall be of lengths and classes/strengths indicated and as required for the calculated loading.

B. Structures materials shall meet ASTM A-36, A-53 Gr. B, A-500 Gr. B, A-572, A-588, A-595, A-633 Gr. E, and A-871. Anchor bolts for structures shall confirm to ASTM A-36 bar with A-563 Gr. A nuts, and A-615 Gr. 75 deformed bar with A-194 Gr. H nuts. Connection bolts shall meet ASTM A-325 Types I and III with Anco locknuts and A-354 Gr. BC with Anco locknuts.

C. Structures shall be fabricated with tolerances in accordance with AISC, and AWS D1.1. Stress critical structures shall meet the requirements of AWS D1.1, Section 9. Deflection critical structures shall meet the requirements of AWS D1.1, Section 8.

D. Structure welds for shaft/baseplate of shaft/splice plate shall be 100% joint penetration for all stress critical structures. All circumferential welds between shaft sections shall be 100% joint penetration. Longitudinal welds other than at a slip joint shall be 60% joint penetration in all materials ¾" thick or less, or 80% joint penetration in all materials thicker than ¾", and shall be 100% joint penetration for a minimum length of six inches from any base plate/splice weld or any circumferential weld requiring 100% joint penetration. Longitudinal welds in slip joints at the female section shall be 100% joint penetration for a minimum length equal to the slip joint design length plus six inches. The weld at the male section shall be 100% joint penetration for a minimum length of 6 inches.

E. Steel Poles
   1. Steel poles shall be designed to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors, shall be hot-dip

galvanized and shall not be painted. Poles shall have tapered tubular members, either round in cross-section or polygonal, and comply with strength calculations performed by a registered professional engineer. Calculations shall be submitted for review. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically accepted. Pole markings shall be approximately 3 to 4 feet above grade and shall include manufacturer, year of manufacture, top and bottom diameters, length, and a loading tree. Attachment requirements shall be provided as indicated, including grounding provisions. Climbing facilities are not required. Bases shall be of the anchor-bolt-mounted type.

F. Pole Line Hardware

1. Zinc-coated hardware shall comply with ANSI C135.1, ANSI C135.2, ANSI C135.4, ANSI C135.14, ANSI C135.17, ANSI C135.22, and ANSI C135.33. Steel hardware shall comply with ASTM A 575 and ASTM A 576. Hardware shall be hot-dip galvanized in accordance with ASTM A 153. Pole-line hardware shall be hot-dip galvanized steel. Washers shall be installed under boltheads and nuts on wood surfaces and elsewhere as required. Washers used on through-bolts and double-arming bolts shall be approximately 2 1/4 inches square and 3/16 inches thick. The diameter of holes in washers shall be the correct standard size for the bolt on which a washer is used. Washers for use under heads of carriage-bolts shall be of the proper size to fit over square shanks of bolts. Eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises shall be used wherever required to support and to protect poles, brackets, crossarms, guy wires, and insulators.

2.9 INSULATORS

A. Insulators shall comply with NEMA HV 2 for general requirements. Suspension insulators shall be used at corners, angles, dead-ends, other areas where line insulators do not provide adequate strength, and as indicated. Mechanical strength of suspension insulators and hardware shall exceed the rated breaking strength of the attached conductors.

B. High-Voltage Line Insulators

1. High-voltage line insulators shall comply with ANSI C29.2, ANSI C29.5, and ANSI C29.6 as applicable. Ratings shall not be lower than the ANSI classes indicated in the following table. Construction shall be a fiberglass rod, ferrous end fittings, and weathersheds constructed of silicone alloy rubber. Dead end insulators shall be designed to up to 15,000 lbs tension without failure.

Voltage Level	Suspension
Up to 5 kV	One 52-1
6 kV to 15 kV	Two 52-2
16 kV to 25 kV	Two 52-3 or 4
26 kV to 35 kV	Three 52-3 or 4
69 kV	Six 52-6

2.10 FUSES AND SWITCHES, HIGH-VOLTAGE

A. Fuse Cutouts
   1. High-voltage fuses and cutouts shall comply with NEMA SG 2 and shall be of the nonloadbreak open type construction and of the heavy -duty type. Open-link cut-outs are not acceptable. Fuses shall be dropout type. Fuse ratings shall be as indicated. Fuse cutouts shall be equipped with mounting brackets suitable for the indicated installations.

B. Group-Operated Load Interrupter Switches
   1. Manually operated (switch handle operated) load interrupter switches shall comply with ANSI C37.32 and shall be of the outdoor, manually-operated, three-pole, single-throw type with either tilting or rotating insulators. Switches shall be equipped with interrupters capable of interrupting currents as indicated. Each switch shall be preassembled for the indicated configuration and mounting. Moving contacts shall be of the high-pressure, limited-area type, designed to ensure continuous surface contact. Switches shall be complete with necessary operating mechanisms, handles, and other items required for manual operation from the ground. Switch operating handles shall be located approximately 3 feet 6 inches above final grade. Insulation of switch operating mechanisms shall include both insulated interphase rod sections and insulated vertical shafts. Each handle shall be provided with a padlock arranged to lock the switch in both the open and the closed position. Gang operated load break switches shall be S&C Alduti-Rupter, or equal.

2.11 SURGE ARRESTORS

A. Surge arrestors shall comply with NEMA LA 1 and IEEE C62.1, IEEE C62.2, and IEEE C62.11, and shall be provided for protection of aerial-to-underground transitions, group-operated load-interrupter switches, transformers and other indicated equipment. Arrestors shall be station class, rated as shown. Arrestors shall be equipped with mounting brackets suitable for the indicated installations. Arrestors shall be of the metal-oxide varistor type suitable for outdoor installations.

2.12 GROUNDING AND BONDING

A. Driven Ground Rods
   1. Ground rods shall be of copper-clad steel not less than 3/4 inch in diameter by 10 feet in length of the sectional type driven full length into the earth.

B. Grounding Conductors
1. Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as the phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.13 WARNING SIGNS

A. Warning signs shall be porcelain enameled steel or equal. Voltage warning signs shall comply with IEEE C2.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Circuits installed in conduits or underground and splices and terminations for medium-voltage cable shall conform to the requirements of Section 16312.

B. Conformance to Codes
The installation shall comply with the requirements and recommendations of IEEE C2 for heavy loading districts, Grade B construction. No reduction in clearance shall be made. The installation shall also comply with the applicable parts of NFPA 70.

C. Verification of Dimensions
The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall notify the A/E of any discrepancy before performing any work.

3.2 POLE INSTALLATION

A. Steel Pole Setting: Poles shall be mounted on cast-in-place foundations.
   1. Cast-In-Place Foundations
      Concrete foundations, sized as indicated, shall have anchor bolts accurately set in foundations using templates supplied by the pole manufacturer. Concrete work and grouting is specified in Division 3. After the concrete

has cured, pole anchor bases shall be set on foundations and leveled by shimming between anchor bases and foundations or by setting anchor bases on leveling nuts and grouting. Poles shall be set plumb. Anchor bolts shall be the manufacturer's standard, and not less than necessary to meet the pole wind loading specified herein and other design requirements.

3.3 EQUIPMENT MOUNTING

A. Equipment supports shall be set parallel or a right angles to lines as required to provide climbing space. Equipment supports shall be located below line construction to provide necessary wire and equipment clearances.

3.4 CONDUCTOR INSTALLATION

A. Line Conductors:
Unless otherwise indicated, conductors shall be installed in accordance with manufacturer's approved tables of sags and tensions. Proper care shall be taken in handling and stringing conductors to avoid abrasions, sharp bends, cuts, kinks, or any possibility of damage to insulation or conductors. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors shall be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension shall be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

B. Connectors and Splices:
Connectors and splices shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be non-corrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors shall be of the solderless pressure type. Non-insulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

C. Conductor-To-Insulator Attachments
Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as indicated in Table III.

Table III Tie-Wire Requirements	
Conductor Copper (AWG)	Tie Wire Soft-Drawn Copper (AWG)
6	8
4 and 2	6
1 through 3/0	4
4/0 and larger	2
ACSR (AWG)	AAAC or AAC (AWG)
Any Size	6 or 4

D. Armor Rods:
Armor rods shall be provided for ACSR conductors. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 200 feet, flat aluminum armor rods may be used. Flat armor rods, not less than 762.0 micrometers by 0.03 by 0.25 inch shall be used on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods shall be not less than 0.05 by 0.30 inches. For span lengths of200 feet or more, preformed round armor rods shall be used. In lieu of armor rods, neoprene coated tie wires designed to protect the conductor from abrasion at connections may be used at Contractor's discretion. Such ties shall also provide a conductor pad.

3.5 CONNECTIONS TO UTILITY LINES

A. The Contractor shall coordinate the work with the Utility Company and shall provide for final connections to the utility electric lines.

3.6 CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS

A. Connections between aerial and underground systems shall be made as shown. Underground cables shall be extended up poles in [guards] [conduit] to cable terminations. Conduits shall be secured to poles by [conduit supports] [two-hole galvanized steel pipe straps] spaced not more than 3 m (10 feet) apart and with one support not more than 300 mm (13 inches) from any bend or termination. Cables shall be supported by devices separate from the conduit or guard, near their point of exit from the riser conduit or guard. Cables guards shall be secured in accordance with the manufacturers published procedure. Risers shall be

equipped with bushings to protect cables.

3.7 GROUNDING

A. Noncurrent-carrying metal parts of equipment and conductor assemblies, such as cable terminations and messengers, metal poles, operating mechanisms of pole top switches, panel enclosures, and other non-current-carrying metal items shall be grounded. Additional grounding of equipment, neutral, and surge arrester grounding systems shall be installed at poles where indicated.

B. Grounding electrodes shall be installed as follows:
   1. Driven rod electrodes - unless otherwise indicated, ground rods shall be located approximately 3 feet out from base of the pole and shall be driven into the earth until the tops of the rods are approximately 1 foot below finished grade. Multiple rods shall be evenly spaced at least 10 feet apart and connected together 600 mm (2 feet) below grade with a minimum No. 6 bare copper conductor.
   2. Pole butt electrodes - Pole butt electrodes shall be installed where indicated, except that this method shall not be the sole grounding electrode at transformer locations. The pole butt electrode shall consist of a coil of at least 12 feet of minimum No. 6 bare copper conductor stapled to the butt of the pole.
   3. Plate electrodes - Plate electrodes shall be installed in accordance with the manufacturer's instructions and IEEE C2 and NFPA 70.
   4. Ground Resistance - The maximum resistance of a [driven ground rod] [pole butt electrode] [plate electrode] shall not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes [interconnected with grounding conductors] [as indicated], to achieve the specified ground resistance. The additional electrodes will be [up to three, [2.4 m (8 feet)] [3 m (10 feet)] rods spaced a minimum of 3 m (10 feet) apart], [a single extension-type rod, 19.1 mm (3/4 inch) diameter, up to 9.1 m (30 feet) long, [driven perpendicular to grade] [coupled and driven with the first rod]. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Engineer shall be notified. Connections below grade shall be exothermically welded. Connections above grade shall be exothermically welded or shall use UL 467 approved connectors.

C. Grounding and Bonding Connections:
   Connections above grade shall be made by the exothermically-welding process or with bolted solderless connectors in compliance with UL 467, and those below grade shall be made by the exothermically welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

D. Grounding Electrode Conductors:
On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Neutrals, surge arresters, and equipment grounding conductors shall be bonded to this conductor. For single grounded or ungrounded systems, provide a grounding conductor for the surge arrester and equipment grounding conductors and a separate grounding conductor for the secondary neutrals. Grounding electrode conductors shall be sized as shown. Secondary system neutral conductors shall be connected directly to the transformer neutral bushings, then connected with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor, as shown. On metal poles, a preformed galvanized steel strap, 5/8 inch wide by 22 gauge minimum by length, secured by a preformed locking method standard with the manufacturer, shall be used to support a grounding electrode conductor installation on the pole and spaced at intervals not exceeding 5 feet with one band not more than 3 inches from each end of the vertical grounding electrode conductor. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

3.8 FIELD TESTING

A. General
Field testing shall be performed in the presence of the Engineer's representative. The Contractor shall notify the Engineer 30 days prior to conducting tests. The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

B. Safety
The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

C. Ground-Resistance Tests
The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std. 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes shall be provided.

D. High-Voltage Preassembled Cable Test

After installation, prior to connection to an existing system, and before the operating test, the high-voltage preassembled cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 7 or NEMA WC 8 for the particular type of cable installed, and shall not exceed the recommendations of IEEE Std. 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

E. Pre-Energization Services

The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

Switches.
Transformers.

F. Operating Tests

After the installation is completed, and at such time as the Engineer may direct, the Contractor shall conduct operating tests for acceptance. The equipment shall be demonstrated to operate in accordance with the specified requirements.

3.9 MANUFACTURER'S FIELD SERVICE

A. Installation Engineer
After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the onsite tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment.

3.10 ACCEPTANCE

A. Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

+ + END OF SECTION + +

SECTION 16440

LOW VOLTAGE MOTOR CONTROL

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Contractor shall furnish and install motor control equipment as specified herein and as shown on the Drawings.

B. Variable Frequency Drives for mechanical and HVAC equipment shall be furnished under Division 15.

1.2 SUBMITTALS

A. Motor control equipment shall be new and the equipment of one manufacturer. Each component is specified by a particular trade name; however, this does not relieve the Contractor of the responsibility of submitting descriptive literature and Shop Drawings for review of all components. Motor control shall be the same brand as power distribution equipment on projects with both.

B. Shop drawings, including layout drawings, complete schematic and composite wiring diagrams, control circuit wiring diagrams and descriptive literature shall be submitted to the Engineer for review. Service manuals shall be submitted on all equipment and shall be bound in 3-ring loose-leaf binders. The manuals shall also include information on accessories such as timers, etc., built in the controls.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Control Equipment
   1. "Allen Bradley"
   2. No substitution.

B. Timers
   1. "Paragon", "Tork", "Intermatic", or equal.

2.2 MOTOR CONTROL CENTERS (MCC)

A. General
   1. Quality of built-in transformers, starters, lighting panelboards, timers, etc. shall be as written elsewhere in this Division unless otherwise noted.

2. Motor Control Center(s) shall consist of one or more enclosed vertical sections joined together to form a rigid, free standing assembly. The construction of the Motor Control Center shall meet the requirements set forth by Underwriters' Laboratories publication UL-845, NEMA publication number ICS-2-322, the National Electrical Code, and color coded.
3. The structure shall be UL listed and labeled as service equipment if applicable. All sections shall bear UL labels.
4. Enclosures shall be NEMA 1 unless otherwise indicated, and each control center suitable for connection to an available fault current of 22,000 RMS symmetrical amperes.

B. Construction
   1. Vertical Sections
      a. Vertical sections shall support the horizontal and vertical buses, combination starter units, covers and doors, and shall be designed to allow for easy rearrangement of units by the purchaser. Vertical sections shall have structural supporting members formed of a minimum of 13 gauge hot-rolled steel. All finished surfaces shall be blemish-free. Where needed, reinforcement structural parts shall be of 10-gauge steel to provide a strong rigid assembly. Each section shall be 90 inches high and shall have 7 gauge steel, 3 inch high removable lifting angle and two 1-1/2 inch high base channels. Complete control center line-ups shall be divided into shipping splits no wider than approximately 60 inches. The lifting angle shall be provided on the top of each shipping split and shall extend the entire width of the shipping split. Lifting angles shall be designed to support the entire weight of the MCC section. Base channels shall be provided with holes to permit bolting the Motor Control Center(s) to the floor. The entire assembly shall be constructed and packaged to withstand all stresses induced in transit and during installation.
      b. Motor Control Centers shall be designed so that matching vertical sections of the same current rating and manufacture can be added later at either end of the line-up without use of transition sections and without difficulty or undue expense. Removable end closing plates shall be provided to close off openings on the end of the Motor Control Center line-up. A removable top plate shall be provided on each vertical section and shall be of one-piece construction for added convenience in cutting conduit holes. The design shall allow use of the standard conduit entrance area without significant sag or deformation of the top plate.
      c. Vertical sections shall be designed to accommodate plug-on units in front-of-board or back-to-back construction as shown on Contract Drawings. Vertical sections housing plug-on units shall be 20 inches wide and shall be 20 inches deep. Wider sections will be permitted only for bolted connection type units not fitting the 20-inch wide sections. Unit mounting area shall be divided into 2 space factor divisions, each approximately 6 inches. NEMA Size 1 and 2

combination starter units shall use only 1 space factor, or 12 inches, of unit mounting space. Vertical sections shall allow for 7 space factors of unit mounting space. Removable blank plates shall cover all unused unit-mounting spaces. Blank plates shall be flanged on all 4 sides and shall be mounted with captive screws. Blank space shall be equipped for future use.

d. Vertical sections shall be provided with both horizontal and vertical wireways. Sufficient clearances shall be provided in the horizontal wireway so that no restriction is encountered in running wires from the vertical to horizontal wireway. Wireways shall be in accordance with the wireway sections contained in this document.

2. Horizontal Wireways
   a. Horizontal wireways shall be provided in the top and bottom of each vertical section and shall be arranged to provide full-length continuity throughout the entire assembly. The top horizontal wireway shall have a cross sectional area of not less than 20 square inches with openings between sections of not less than 11-1/2 square inches. The bottom horizontal wireway shall extend through the length and depth of the vertical sections and shall also be provided with openings of not less than 11-1/2 square inches to allow for full length continuity throughout the entire assembly. The bottom horizontal wireway height shall be not less than 9 1/4 inches. Covers for all wireways shall be equipped with captive type screws to prevent loss of hardware during installation. All wireways shall be isolated from the bus bars.
3. Vertical Wireways
   a. A vertical wire trough shall be located on the right -hand side of each vertical section and shall extend from the top horizontal wireway to the bottom of the available unit mounting space. Each vertical wire trough shall have a cross sectional area of not less than 19 square inches and shall be isolated from the bus bars to guard against accidental contact. A separately hinged door having captive type screws shall cover the vertical wire trough to provide easy access to control wiring without disturbing control units.
   b. Reusable wire ties shall be furnished in each vertical wire trough for the purpose of grouping and securely holding wires in place for a neat and orderly installation.
4. Busbars
   a. A continuous main three-conductor horizontal bus shall be provided over the full length of the control center. A fully rated horizontal neutral bus (1200 ampere maximum) shall also be supplied over the full length of the Motor Control Center. When necessary, the bus shall be split to allow for ease in moving and handling. Splice bars will be supplied to join the bus wherever a split has been made. All splice connections shall be made with at least two bolts and shall employ the use of Belleville washers in the connection. Horizontal bus bars shall be mounted edgewise and supported by insulated bus supports.

b. For distribution of power from the main horizontal bus to each unit compartment, a three-phase vertical bus shall be provided. The vertical bus shall be firmly bolted to the horizontal bus for permanent contact.

c. The main horizontal and vertical buses shall be made of aluminum and the entire length shall be electrolytically tin plated to provide maximum protection to the bus bars from normal or adverse atmospheric conditions.

d. Bus supports shall be formed of high strength glass reinforced alkyd material. Bus supports shall have generous surface clearances in the vertical plane to shed dust and maintain dielectric integrity. Bus supports and insulators shall be red to indicate proximity of energized bus parts.

e. Horizontal and vertical buses shall have continuous current ratings adequate to handle all loads as shown on the one line diagram in the Contract Drawings. Continuous current ratings shall be in accordance with temperature rise specifications established by UL, ANSI, and NEMA standards.

f. A copper ground lug shall be provided in each incoming line vertical section capable of accepting a #8 to 250 MCM cable. A horizontal copper grounding bus shall be provided in each section of the Motor Control Center. Horizontal grounding bus shall run continuously throughout the control center except where splits are necessary for ease of shipment and handling in which case splice bars shall be provided. Grounding bus shall be tin plated copper and have a cross sectional area equal to 28% of the main horizontal bus cross sectional area. Horizontal ground bus shall be located at the bottom of the Motor Control Center.

5. Bus Barriers

a. Insulated horizontal and vertical bus barriers shall be furnished to reduce the hazard of accidental contact with the bus. Barriers shall have a red color to indicate proximity of energized buses. Vertical bus barriers shall have interlocking front and back pieces to give added protection on all sides and shall segregate the phases to reduce the possibility of accidental “flash over”. Small, separate openings in the vertical bus barriers shall permit unit plug-on contacts to pass through and engage the vertical bus bars. Bottom bus covers shall be provided below the vertical bus to protect the ends of the bus from accidental contact with fish tapes or other items entering from the bottom of the enclosure. Unused plug-on openings in the bus shall have plastic snap-in closing plates for added safety.

6. Main and Feeder Circuit Breaker Units

a. Main Circuit Breaker Units shall be located in the top or bottom most unit space of the section to accommodate the user’s cables entering the Motor Control Center as indicated on the Contract Documents.

b. Units shall be inverse time (thermal magnetic trip for up to 400Amps and electronic trip for 600Amps and above) circuit breakers.

c. Units shall be front accessible and have removable protective barriers on the line side to reduce accidental contact of line terminals.

d. The minimum interrupting ratings of the circuit breakers shall be at least equal to the available short circuit current at the line terminals. Circuit breaker ratings, and modifications, shall be as shown on the Contract Drawings.

e. Units shall have continuous current rating based on 40degree C ambient.

f. Units shall be equipped with integral, adjustable ground fault protection (if required).

7. Units

a. Combination starter units shall consist of Size 1 minimum full voltage magnetic starters, autotransformer reduced voltage starters, molded case magnetic-only circuit breakers, and auxiliary control devices, as required and/or shown on the one-line and elementary diagrams. Pilot light assemblies (push-to-test) shall be transformer type. All auxiliary equipment, except that which is specified for mounting on the door, shall be mounted within the compartment. All units shall be provided with unit doors, unit support pans, unit saddles and unit disconnect operators as outlined in this Specification. Each unit compartment shall be enclosed and isolated from adjacent units, buses and wireways except for openings for conductor entrance into units. Units shall be designed and constructed so that any fault will be localized within the compartment. All units shall be UL listed for minimum of 22,000 amperes RMS symmetrical fault withstand ability.

b. Plug-on combination starter units of the same NEMA size and branch feeder units of the same trip size shall be readily interchangeable with each other. It shall be possible to withdraw each plug-on unit to a de-energized position with the unit still being supported by the structure. It shall be possible to lock the unit in this position with one padlock.

c. Full voltage non-reversing combination starter units shall have the following minimum space factor requirements, shall be provided with plug-on connections and shall be provided with ample space for customer wiring room:

	Circuit Breaker Space Factor
Size 1	1
Size 2	1
Size 3	1-1/2
Size 4	2

8. Unit Plug-On

a. For convenient unit connection to bus bars, unit plug-on contacts shall be provided on the following units:

1) For circuit breaker type units; full voltage starters, size 4 and smaller; auto-transformer reduced voltage starters, size 4 and smaller; part winding reduced voltage starters, size 4PW and smaller; branch circuit units, 225 ampere and smaller.

b. The plug-on connection for each phase shall be of a high quality two-point connection and shall be designed to tighten around the vertical bus bar during a heavy current surge. For trouble-free connections, the plug-on fingers shall be silver plated and coated with a compound to assure a low resistance connection. Contact fingers shall be of a floating and self-aligning design to allow solid seating onto the vertical bus bars.

c. Starters NEMA size 4 and larger shall bolt directly to the vertical bus bars, circuit breakers rated higher than 225 amps shall also bolt directly to the bus bars.

9. Unit Doors

a. Each unit shall have a door securely mounted with rugged concealed-type hinges which allow the door to swing open a minimum of 112^{o} for unit maintenance and withdrawal. Doors shall be fastened to the structure so that they remain in place when a unit is withdrawn and may be closed to cover the unit space when the unit has been temporarily removed. Doors shall be held closed with captive type screws which engage self-aligning cage nuts. These screws shall provide at least two threads of engagement to hold doors closed under fault conditions. Each unit door shall be interlocked with it's disconnect mechanism to prevent the door from opening when the unit is energized. A defeater mechanism shall be provided for defeating this interlock by authorized personnel. Removable door panels held with captive type screws shall be provided on starter unit doors for mounting push buttons, selector switches or pilot lights. Blank door panels capable of accepting future pilot devices shall be furnished when pilot devices are not originally specified for starter units. Each starter unit door shall house an external low-profile overload reset button for resetting the overload relay in the event of tripping.

10. Unit Support Pan

a. Each plug-on unit shall be supported and guided by a tilt and lift-out removable pan so that unit rearrangement can be easily accomplished. For easy unit installation and rearrangement, transfer of this unit support pan from one location to another shall be accomplished with ease after the control unit and door have been removed.

11. Unit Saddles

a. Each plug-on unit shall have a saddle of 14 gauge hot rolled steel designed and constructed to physically isolate the unit from the bus compartment and adjacent units. Saddlers shall be equipped with captive, self-aligning mounting screws which shall hold the unit securely in place during shipment. Flanged edges shall be provided on each saddle to facilitate unit removal.

12. Disconnect Operators

a. An external operator handle shall be supplied for each switch or breaker. This mechanism shall be engaged with the switch or breaker at all times regardless of unit door position to prevent false circuit indication. The operator handle shall be color coded to display red in the "ON" position and black in the "OFF" position. The operator handle shall have a conventional up-down motion and shall be designed so that the down position will indicate the unit is "OFF". For added safety it shall be possible to lock this handle in the "OFF" position with up to three padlocks. The operator handle shall be interlocked with the unit door to prevent switching the unit to "ON" while the unit door is open. A defeater mechanism shall be provided for the purpose of defeating this interlock by a deliberate act of an electrician should he desire to observe the operation of the operator handle assembly or the unit components. Operators shall not be higher than 6'-6" above finished floor elevation, as installed.

13. Wiring
    a. The motor control center wiring shall be NEMA Class II, Type B.
    b. All wiring to the terminal strips from outside the MCC shall be made with spade type terminals of the proper size and rating for the wire used. Pull apart terminal blocks shall be provided in unit spaces of motor starters that contain field wiring energized from a remote source to comply with NEC Article 430-74.
14. Finish
    a. The finish shall be manufacturer's standard gray enamel applied over a rust inhibiting phosphate primer.
15. Optional Modifications and Accessories
    a. Additional modifications and accessories shall be as listed and specified on the Contract Drawings.
16. Identification
    a. A control center identification nameplate describing section catalog numbers and characteristics shall be fastened on the vertical wire trough door of every section. Each control center unit shall have its own identification nameplate fastened to the unit saddle. These nameplates shall have suitable references to factory records for efficient communication with supplier. Each control center unit shall also have an engraved Bakelite nameplate fastened to the outside of each unit door inscribed as written on the Contract Drawings for ease in identification and for making changes when regrouping units. An overall structure nameplate is also required.
17. Metering
    a. All voltmeters, ammeters, wattmeters, current transformers, potential transformers and phase selector switches shall be furnished as shown on the Contract Drawings. Meter accuracy shall be $\pm$ 1 percent. Solid state metering shall be as specified this section.

C. Starters and Overcurrent Protective Devices
    1. Magnetic Starters

a. Magnetic starters shall be furnished in all combination starter units unless otherwise indicated on Contract Drawings. Starter Sizes 1 through 4 shall employ the use of a bell-crank lever design to transform vertical action of the armature into horizontal action of the contact carriers and thus minimize contact bounce and produce extra long contact life. Thermal overload relays on starters shall be ambient temperature compensated bimetallic type with selector for either auto or manual reset. Overload heater units shall be provided in each starter unit. Overload relay heater schedules shall be provided on each starter unit.

2. Circuit Breakers
   a. Type FA, KA, LA, MA and PA molded case circuit breakers shall be furnished in all starter and branch feeder units using circuit breakers as a disconnect means. All circuit breakers will have a push-to-trip test feature for testing and exercising the circuit breaker trip mechanism.
3. Starters shall conform to requirements listed under individually mounted Motor Control Devices, hereinafter.

D. Lighting Panelboards
   1. Lighting panelboards shall be as specified in other section of this Division. Lighting panelboard unit doors shall be held closed with captive latches that may easily be operated without the use of tools, i.e., wing nuts, handle, etc.

E. Transformers
   1. 480 volt primary, 120/240 volt or 120/208 volt secondary transformers shall be as specified in other sections of this Division.

F. Power Factor Correction Capacitors
   1. UL listed power factor correction capacitors shall be provided in the Motor Control Centers where indicated on the Contract Drawings, wired into each motor starter for all 3 phase process equipment as indicated in the one-line diagram in the Drawings, so that they are switched with the motors. They shall be wired in accordance with the NEC and sized based on proper motor rpm for correction to 90-95 percent, from no load power factor. Totally enclosed capacitors mounted atop Motor Control Centers shall be utilized in those instances where their addition within unit spaces would substantially increase the length of structures from that shown on the Contract Drawings. Capacitors shall be fused, equipped with discharge resistors and pilot light assemblies visible without opening any doors to indicate blown fuses.

G. Electronic Circuit Monitors
   1. Circuit Monitor Installation
      a. Electronic circuit monitors shall be installed by the equipment manufacturer for all circuits as indicated on the Contract Drawings.
      b. All control power, CT, PT, and communications wire shall be factory installed and harnessed within the lineup.

c. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's shop drawings must clearly identify the interconnection requirements, including wire type, to be used.
d. This equipment shall be Square D Power Logic, Westinghouse IQ Data Plus II, General Electric, or equal.

2. Circuit Monitor Characteristics
   a. The electronic circuit monitors shall accept inputs from industry standard instrument transformers (120 VAC secondary PTs and 5A secondary CTs).
   b. The current and voltage signals shall be digitally sampled at a rate high enough to provide accurate rms sensing and valid data for waveform analysis beyond the 30th harmonic (fundamental of 60 Hz).
   c. All setup parameters required by the circuit monitors shall be stored in nonvolatile memory (no battery backup) and retained in the event of a control power interruption.
   d. The circuit monitor shall also maintain, in nonvolatile memory, a maximum and minimum value for each of the instantaneous values reported, as well as the time and date of the highest peak for all of the peak demand readings.
   e. The circuit monitors shall be equipped with an integral LED display to provide local access to metered quantities.
   f. The following instantaneous readings shall be reported by the circuit monitor:
      1) Frequency
      2) Temperature
      3) Current, per phase rms
      4) Current, 3-phase average rms
      5) Current, apparent rms
      6) Voltage, phase-to-phase & phase-to-neutral
      7) Power factor, per phase
      8) Power factor, 3-phase total
      9) Real power, 3-phase total
      10) Reactive power, 3-phase total
      11) Apparent power, 3-phase total
   g. The following demand readings shall be reported by the circuit monitor:
      1) Average demand current, per phase
      2) Peak demand current, per phase
      3) Average demand, real power
      4) Predicted demand, real power
      5) Peak demand, real power
   h. The following energy readings shall be reported by the circuit monitor:
      1) Accumulated energy
      2) Accumulated reactive energy

3. Waveform Capture Capability

a. All electronic circuit monitors shall include waveform capture capability.
b. Upon a user-initiated command, the circuit monitor shall capture and store, in nonvolatile memory, 3-phase voltage and current samples consisting of 256 data points each.
c. These data points shall represent at least four cycles of each current or voltage waveform.
d. These samples shall be evenly gathered from three voltage and three current phases such that the original power signals with proper magnitude and phase relationships may be reconstructed.
e. It shall be possible to recreate the original power signal from the stored data with sufficient accuracy such that steady-state power harmonic analysis will provide valid information on harmonic content for up to the 30th harmonic of the fundamental power frequency.

4. Connecting and Networking Circuit Monitors
   a. All data and calculated values stored in the circuit monitor shall be accessible to external devices by means of an RS485/RS422 serial communications port built into the circuit monitor.
   b. It shall be possible to connect from one communications port to another such that up to 16 electronic circuit monitors may be connected to form a continuous string extending up to 10,000 feet.
   c. These strings shall form individual data transfer networks that comply with the RS485 multi-drop communications standards.
   d. Communication rates on this network shall be adjustable up to 19.2 Kbaud to ensure acceptable throughput of data.
   e. It shall be possible to connect up to 100 of these networks together by means of network interface modules to form a high speed power monitoring, data acquisition and control network.
5. System Display
   a. The circuit monitor shall include an LED readout which will allow local display of the following electrical parameters:
      1) Current, per phase rms
      2) Voltage, phase-to-phase & phase-to-neutral
      3) Real power, 3-phase total
      4) Reactive power, 3-phase total
      5) Apparent power, 3-phase total
      6) Power factor, 3-phase total & per phase
      7) Frequency
      8) Peak demand current, per phase
      9) Peak demand, real power
      10) Accumulated Energy, (MWH and MVARH)
   b. Reset of the following electrical parameters shall also be allowed from the front of the circuit monitor:
      1) Peak demand current
      2) Peak demand power
      3) Energy (MWH)
      4) Reactive energy (MVARH)

c. Circuit monitor setup for system requirements shall be allowed from the front of the circuit monitor. Setup provisions shall include:
   1) CT rating (xxxx:5)
   2) PT rating (xxxx:120)
   3) System type (3-wire and 4-wire)
   4) Demand interval (5-60 min.)

d. All reset and setup functions shall be keyswitch-protected to prevent unauthorized/accidental changes.

e. System display units shall be installed by the manufacturer in the equipment as indicated on the drawings.

f. The system display units shall be flush mounted on door panels.

g. The system display unit shall utilize a 4-line by 20-character, high contrast LCD technology display with backlighting to provide high reliability and superior readability in all light conditions.

2.3 INDIVIDUALLY MOUNTED MOTOR CONTROL DEVICES (480, 208, 240 OR 120 VOLT)

A. General

1. All motor control equipment shall be new and the product of 1 manufacturer. All individually mounted disconnects, push-button stations, latchout stations, starters, etc., indoors shall be mounted on a 1 inch galvanized unistrut, 1 inch Kindorf channel, or equal to provide an air space at rear. Outside mounted equipment shall utilize 1-inch aluminum strut as required in 16070.

B. Starters

1. General
   a. All starters shall be of the voltage rating, type, and sized for the motor size shown in these Specifications and/or on the Contract Drawings. For enclosure type see the Contract Drawings. All starters shall be of the magnetic type. Should a piece of electrically driven equipment be furnished with a larger motor than shown on the Contract Drawings, the proper size combination starter shall be provided for the equipment supplied, at no extra cost to the Owner.
   b. See the Contract Drawings for the auxiliary equipment to be furnished. Maximum control voltage shall be 120 volts, a-c. Minimum starter size shall be NEMA Size 1.
2. Overloads
   a. Each starter shall have a thermal overload device in each ungrounded leg. The overload shall be of the “Ambient compensated Bi-metallic”, thermal element type. All overloads shall be of the manual reset type and shall be reset without opening the starter enclosure. Heaters will be sized for the proper temperature rise of the motor that it is being used on. Heaters for general service shall be of the standard trip type. All integral horsepower motors, 15 horsepower and over, require

thermal elements embedded in the windings. See Motor Specifications, this division.

3. Contactors
    a. All contactors for motor starters shall be of the a-c magnetic type with "undervoltage" protection when used in conjunction with momentary contact push-button control and "undervoltage" release when used with maintained contact push-button control.
    b. Contactor size shall be in accordance with NEMA Standards for the motor controlled and shall be horsepower rated.
    c. Contacts shall be of the heavy duty silver-to-silver type and shall be totally enclosed in individual arc quenching chambers. Contacts shall be easily accessible for replacement.
    d. The contactor coil shall be of the vacuum impregnated or epoxy resin type, moisture resistant and corrosion proof.
4. Auto-transformer
    a. The auto-transformer for reduced voltage starting shall be of the dry type consisting of two windings connected in open delta. Only "closed" circuit transition is acceptable unless noted otherwise on the Contract Drawings. Taps for 50 horsepower and below shall be 65 percent and 80 percent. For above 50 horsepower a 50 percent tap shall also be provided. All autotransformers shall be thermally protected with a thermostatic switch in each winding wired into the starter to shut the starting sequence down on overheating.

C. Control Stations
1. General
    a. Control stations shall be heavy duty, maintained or momentary contact type, as noted on the Contract Drawings. Contacts shall be silver alloy, double break type. The number and marking of controls shall be as shown on the Contract Drawings. Enclosures shall be NEMA I for indoor and NEMA 4 for outdoor mounting, unless otherwise noted on the Contract Drawings. All control stations shall operate on 120 volt, a-c maximum, unless otherwise designated on the Contract Drawings. "Latch-out" facilities shall be provided where called for in these Specifications and/or on the Contract Drawings.
2. Maintained Contact
    a. Maintained contact control switches shall be marked "On" and "Off". The button pushed shall remain in and push the other button out until the other button is pushed. In general, they are to be used for hand control of motors which have to operate continuously and restart whenever power is off then resumed, without any manual operator. This is needed for motors which have to operate continuously in the absence of an operator.
3. Momentary Contact
    a. Momentary contact control push-button switches shall be marked "start" and "stop". Pushbuttons shall spring out whenever pushed. If the circuit is dropped for any reason, operation cannot be resumed

until a “start” push-button is pushed. In general, they are to be used for hand control of motors which are desired to operate intermittently in the presence of the operator and stop and start independently from more than one parallel control location.

4. Latchout Only
   a. Latchout only switches shall have a spring return on the momentary “stop” push-button only with a hold in plate used inside and a nail hole lock when used outside to disconnect hand and/or automatic control circuit.

D. Circuit Breakers
   1. Circuit breakers shall be molded case type. Trip elements of multi-pole breakers shall be effectively insulated from one another. Multi-pole breakers shall be designed so that an overload on any one pole shall open all poles simultaneously.
   2. The breaker operating mechanism shall be the quick-make, quick-break type and shall be entirely trip free to prevent the contacts being held in a closed position against a short circuit.
   3. Breakers not used with combination motor starters shall be of the thermal magnetic type with a thermal bimetallic element for time delayed overload protection and a magnetic element for short circuit protection.
   4. The breaker shall be trip indicating with the trip position midway between the “On” and “Off” positions.
   5. Breakers for combination starters shall be 100 amp frame or larger. All breakers for combination starters shall have an adjustable magnetic trip element of the motor circuit protector type.

   6. Breakers for combination starters shall be F frame or larger. All breakers shall have adjustable magnetic trip elements. Circuit breakers K frame and larger shall have interchangeable thermal-magnetic trip elements.

E. Safety Switches
   1. Safety switches shall be as specified in Section 16170. All safety switches at motor locations are of the nonfused type unless otherwise noted.

F. Selector Switches
   1. Hand-off-automatic type selector switches shall be of oil-tight construction and shall have 3 positions. The switch must not have a spring loaded return. It shall be of the “quick-make”, “quick-break” type.

G. Manual Motor Starting Switches
   1. Manual motor starting switches for the control of fractional horsepower motors shall be single pole, and shall be provided with a thermal heater of the correct size for the load controlled. Each starting switch shall be mounted where shown on the Contract Drawings. Where they are used for rotating equipment such as grinders, they shall be equipped with low voltage protection, and required manual reset after power failure. As an alternate to

low voltage protection built-in, a "Safety Restart Plug" may be utilized, available from Mitchell Instrument Company.

H. Limit Switches
   1. Where limit switches are called for in these Specifications, they shall be the double pole, oil-tight type, suitable for the type mounting required.

I. Drum Switches
   1. Drum switches shall be used where called for on the Contract Drawings, for reversing fractional horsepower motors and shall be for constant speed use. They shall be NEMA 4 enclosed and supplied with a ball lever handle. The switches shall be 3 position, forward, off, and reverse, permanently so labeled. They shall be non-spring return. A push-pull interlock shall be provided such that pushing the handle down drops out the magnetic starter and permits the drum switch to be operated; however, the starter will not reclose until the handle is pulled back up.

J. Alarm Horns
   1. Alarm horns, where called for on the Contract Drawings, shall be weatherproof, suitable for surface mounting and shall be provided with a silence button. Alarm horn shall be Edwards 876 series with 103dB at 10 feet, Federal, Signal, or equal.

K. Cable Reels
   1. Cable reels shall be heavy gauge steel construction, weather tight and dust-tight with safety declutching driving hub, rugged 4-roller guide outlet and permanent lubrication. The guide arm shall be swing type for 2 way cable payout. Cable shall be extra hard usage type, 12 gauge minimum, number of conductors and length as required for the installation. A safety chain shall be connected from the reel to the supporting structure and strain relief shall be supplied on all cables. Reels shall be Daniel Woodhead, Appleton, or equal.

L. Timing Relays
   1. Time delay relays shall have an adjustable timing range as shown on the Contract Drawings. The time delay shall be after energizing timer coil. Timing relays shall be Agastat, Square D, or equal.

M. Pilot Lights
   1. Pilot lights shall be LED style with green lenses for on indication, and red for alarm indication.

2.5 TIMERS

A. Timers for various services required in the motor control equipment shall be Paragon, Tork or equal as indicated in control circuits shown on the Drawings.

B. Timers requiring tripping pins shall be supplied with enough pins to completely fill all locations on the dial face.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Motor Control Centers
   1. Ends of MCC(s) shall be closed with 1/4" mesh hardware cloth and galvanized or aluminized insect screen or sill covers to prevent the entrance of rodents and large insects into the MCC housing(s).
   2. Each MCC shall be provided with a 4" high concrete pad.
   3. Each MCC shall be secured to sills imbedded in concrete pads.
   4. One inch air space (min.) shall be allowed between back of MCC(s) and wall surface.
   5. Lifting-eyes in tops of MCC(s) section shall be removed (and retained) and the threaded openings closed with stainless cap screws and plastic washers or plastic seals provided for that purpose by the MCC(s) manufacturer.
   6. In installations where conduit runs to electrical equipment emanate from the top of MCC(s) there shall be provided additional wiring space in the form of metal trough(s) of the same metal housing(s) dimensions and details. Trough(s) shall be provided by the manufacturer of the MCC(s).

B. Individually Mounted Motor Control Devices (480, 208, 240, or 120 Volt)
   1. Each motor disconnect shall be located as near as possible to its respective motor.
   2. Remote control station at or near motor shall be mounted near its respective motor, adjacent to the motor disconnect.

3.2 EXTRA STOCK/SPARE PARTS

A. Provide the following spare parts:

10	fuses of each type/amperage used
1	pilot light lamp for each pilot light socket assembly provided
1	control transformer for each size utilized

+ + END OF SECTION + +

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SECTION 16442

PANELBOARDS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section of the Technical Specifications includes furnishing all labor, materials, equipment, and incidentals required for the installation of all lighting and distribution panelboards as hereinafter specified and as shown on the Contract Drawings.

B. The panelboards for installation under this Contract shall be selected from the following types with the panel voltage and main sizes the determining factors. All panelboards shall be by the same manufacturer.

C. Circuit breakers of size and type shown on Contract Drawings and described herein shall be provided with the panelboards.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. "Square D", "Eaton", "Siemens", or equal.

2.2 EQUIPMENT

A. Rating
   1. Panelboard ratings shall be as shown on the Contract Drawings. All panelboards shall be rated for the intended voltage.

B. Standards
   1. Panelboards shall be in accordance with the Underwriter Laboratories, Inc. "Standard for Panelboards" and "Standard for Cabinets and Boxes" and shall be so labeled where procedures exist. Panelboards shall also comply with NEMA Standard for Panelboards and the National Electrical Code.

C. Panelboard Construction (NEMA 1)
   1. Interiors
      a. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and all shall be suitable for copper or aluminum wire of the sizes indicated.

b. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping.
c. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.
d. A nameplate shall be provided listing panel type, number of circuit-breakers and ratings.

2. Bussing
   a. Bus-bars for the mains shall be of copper. Full size neutral bars shall be included. Bus-bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction. Cross connectors shall be copper.
   b. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
   c. Spaces for future circuit-breakers shall be bussed for the maximum device that can be fitted into them.
   d. Separate neutral and ground bus shall be provided, insulated and isolated from each other.
3. Boxes
   a. Surface mounted boxes shall be painted to match the trim. Boxes shall be of sufficient size to provide a minimum gutter space of 4 inches on all sides.
   b. Surface mounted boxes shall have an internal and external finish as hereinafter specified. Surface mounted boxes shall be field punched for conduit entrances.
   c. At least 4 interior mounting studs shall be provided.
4. Trims
   a. Hinged doors covering all circuit-breaker handles shall be included in all panel trims.
   b. Doors shall have semi flush type cylinder lock and catch, except that doors over 43 inches in height shall have a vault handle and 3-point catch, complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed. Two keys shall be supplied for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.
   c. The trims shall be fabricated from code gauge sheet steel.
   d. All exterior and interior steel surfaces of the panelboard shall be properly cleaned and finished with manufacturer's standard gray paint over a rust-inhibiting phosphatized coating. The finish paint shall be of a type to which field applied paint will adhere without cracking or peeling.
   e. Surface trims shall have the same width and height as the box. Trims shall be fastened with quarter turn clamps.

D. Overcurrent Protective Devices (Circuit Breakers)
   1. Panelboards shall be equipped with circuit-breakers with frame size and trip settings as shown on the Contract Drawings.
   2. Circuit-breakers shall be molded case, bolt-in, thermal-magnetic trip.
   3. Circuit-breakers used in 120/208 volt panelboards shall have an interrupting capacity of not less than 10,000 amperes, RMS symmetrical.
   4. Circuit-breakers used in 480 volt panelboards shall have an interrupting capacity of not less than 14,000 amperes, RMS symmetrical.
   5. GFCI (ground fault circuit interrupter) shall be provided for circuits where indicated on the Contract Drawings. GFCI units shall be 1-pole, 120 volt, molded case, bolt-on circuit-breakers, incorporating a solid state ground fault interrupter circuit insulated and isolated from the circuit-breaker mechanism. The unit shall be UL listed Class A Group I device (5 milliamp sensitivity, 25 millisecond trip time), and an interrupting capacity of 10,000 amperes RMS.
   6. Trip elements of multi-pole breakers shall be effectively insulated from one another. Multi-pole breakers shall be designed so that an overload on any pole shall open all poles simultaneously.
   7. The breaker operating mechanism shall be the quick-make, quick-break type and shall be entirely trip free to prevent the contacts being held in a closed position against a short circuit.
   8. Breakers shall have a thermal bimetallic element for time delayed overload protection and a magnetic element for short circuit protection.
   9. The breaker shall be trip indicating with the trip position midway between the “On” and “Off” positions.
   10. Breakers for power distribution panels shall be F frame or larger. All breakers rated above 225 amps shall have interchangeable magnetic trip elements.
   11. All breakers shall be UL listed, and conform to requirements of NEMA Standards.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Boxes for surface mounted panelboards shall be mounted so there is at least 2 inch air space between the box and the mounting surface.

B. Circuit directories shall be typed giving location and nature of load served.

C. Each panelboard shall be nameplated with plastic engraved nameplates stating the panel’s name, voltage, and the name of panel serving the panel. Nameplates shall be secured by use of stainless steel screws.

+ + END OF SECTION + +

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SECTION 16444

SOLID STATE REDUCED VOLTAGE MOTOR CONTROL

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Provide all labor, materials, equipment, and services required to furnish and install solid- state motor starters as shown on the Contract Drawings and as specified herein.

1.2 RELATED WORK

A. Special requirements for materials and equipment are given in Divisions 0 and 1.

B. Painting is specified in Division 9.

C. Process equipment is specified in Division 11.

D. Special sequence or schedule requirements (if any) are specified in Section 01010 - Summary of Work.

1.3 SUBMITTALS

A. Shop Drawings, operating and maintenance instructions, and other items needed to establish compliance with the Contract Drawings and these Specifications shall be submitted to the Engineer in accordance with Project General and/or Special Conditions. As a minimum, submittals shall include descriptive literature, service manuals, enclosure fabrication details, dimensions, weights, component layout drawings, front enclosure layout and nameplate engraving, enclosure paint systems and color, materials of construction, and wiring schematics, all tailored to this project.

1.4 SYSTEMS DESCRIPTION

A. Motors as indicated in the Contract Drawings shall be provided with solid-state starters as specified herein to limit power line disturbances and voltage drop on motor start-up.

B. The Contractor shall be responsible for coordinating the starter with driven equipment ratings and assuring compatibility. The Contractor shall furnish a copy of driven equipment shop drawings to the starter manufacturer and confirm that the necessary coordination of ratings has been accomplished.

1.5 QUALIFICATIONS

A. This equipment shall be furnished by a single manufacturer who is experienced, reputable and qualified in the manufacture of the equipment to be furnished. The equipment shall be manufactured by Allen Bradley, Satin-American, Nordic, Square D, or equal.

1.6 WARRANTY

A. This equipment shall have a warranty which shall be one (1) year, and shall run concurrently with the Contractor warranty on the entire project.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. The soft starter shall be provided by the manufacturer in an enclosure rated as NEMA Type 12 for Industrial use.
   1. Enclosure shall include a door mounted digital keypad for adjusting the soft start parameters and viewing the motor, soft start and fault status without opening the enclosure door.
   2. Provisions shall be available for padlocking the enclosure door.

B. The enclosed product shall be provided complete with one of the following overcurrent protective devices (OCPDs) for Type 1 short circuit protection:
   1. Molded case disconnect switch and in line fuse block for RK Type power fuses from 10 to 600 amps or Class L power fuses from 601 to 1600 amps. Short circuit withstand rating shall be 65K AIC.
   2. Magnetic only circuit breaker. Short circuit withstand rating shall be based on the motor horsepower as defined in UL 508.

C. The motor must be automatically protected from solid-state component failure by the following means:
   1. Shunt trip coil to trip disconnect in the event of a controller fault condition, including a shorted thyristor.
   2. Isolation contactor that opens when the motor is stopped or when the controller detects a fault condition, including a shorted thyristor.

D. The soft start shall utilize a thyristor (SCR) bridge consisting of at least two SCRs per phase to control the starting and stopping of industry standard motors (NEMA Design B).

E. The soft start shall provide torque control for linear acceleration without external feedback independent of motor load or type of application. The gating of the thyristors will be controlled in such a manner to ensure smooth and stable acceleration ramp.

F. The soft start shall be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCRs. Analog control algorithms shall not be allowed.

G. All soft start power ratings will utilize the same control module.

H. A shorting contactor shall be supplied with soft starts 47 amps or above when in a Type 12 enclosure. Protective features and deceleration control options integral to the soft start shall be available even when the shorting contactor is employed.

2.2 MOTOR DATA

A. Verify actual motor nameplate values prior to manufacturing of the soft starts.

2. 3 RATINGS

A. The soft start shall be designed to operate in an ambient temperature 0°C to 40°C. For ambient temperatures between 40°C and 60°C, derate the current by 1.2% per °C above 40°C.

B. Storage temperature range shall be -25°C to 70°C.

C. Maximum relative humidity shall be 93% at 40°C, non-condensing.

D. The soft start shall be designed to operate in altitudes up to 3300ft. For higher altitudes, derate by 0.5% for each additional 330ft.

E. The soft start shall be capable of operation within +/-10% of nominal voltage rating.

F. The soft start shall automatically adapt for operation at 50 or 60 Hz. Frequency tolerance shall be +/- 5% when starting and +5% or -15% during steady state operation.

G. The soft start shall be capable of supplying 300% of rated full load current for 30 seconds at maximum ambient temperature.

H. The SCRs shall have a minimum P.I.V. rating of 1400 Vac. Lower rated SCRs with protection by MOVs are not acceptable.

2.4 ADJUSTMENTS AND CONFIGURATIONS

A. All dialogue functions, display units, remote functions, terminal blocks, configuration switches and adjustment potentiometers shall be accessible on the

front of the control module. Exposure to control circuit boards or electrical power devices during routine adjustments shall be prohibited.

B. Digital indication shall provide, as a minimum, the following conditions:
   1. Soft start status - ready, starting/stopping, run.
   2. Motor status - current, torque, thermal state, power factor.
   3. Fault status - Motor thermal overload, starter thermal fault, phase fault, frequency fault, supply fault, locked rotor fault, motor underload, max start time exceeded, external fault, serial link fault, phase inversion, internal failure, overcurrent.

C. The starter shall be preset to the following, for operation without adjustment in most applications:
   1. Torque acceleration ramp of 10 seconds.
   2. Current limitation to 300% of the motor full load current rating.
   3. Class 10 overload protection.
   4. Motor current preset per NEC and UL tables for standard HP motors.

D. A digital keypad shall be utilized configure the following operating parameters as required:
   1. Motor full load amps adjustable from 50 to 130% of the controller's rating.
   2. Current limitation on starting adjustable from 1.5 to 7.0 times rated motor current, not to exceed 5.0 times the controller rating.
   3. Torque ramp adjustable from 1 to 60 seconds.
   4. Initial torque adjustable from 10 to 100% of nominal motor torque.
   5. Torque limit adjustable from 10 to 200% of nominal motor torque.
   6. Maximum start time adjustable from 10 to 999 seconds.
   7. Voltage boost adjustable from 50 to 100% of the nominal supply voltage.
   8. Selection of freewheel, soft stop or braking.
   9. Adjustable soft stop torque ramp time from 1 to 60 seconds.
   10. Threshold to change to freewheel following a soft stop from 0 to 100% of the nominal motor torque.
   11. Braking torque level adjustable from 0 to 100% effectiveness.
   12. Selection of Class 2, 10, 10A, 15, 20, 25 or 30 motor thermal overload protection.

E. A digital keypad shall be utilized configure the following controller parameters as required:
   1. Selectable automatic reset operation.
   2. Cancellation of the torque control loop for multi motor installations.
   3. Adjustment of the stator loss estimation for specialty motors.
   4. Assignment of controller inputs and outputs.
   5. Activation of phase reversal protection.
   6. Reset of motor thermal state.
   7. Return to factory settings.
   8. Activation of test mode for use with low power motors.

9. Indication of elapsed time in hours of starting, running and stopping.

F. Output relays shall provide the following status indications:
   1. One form A (N.O.) and one form B (N.C.) minimum for indication of fault or control of an isolation contactor.
   2. One form A (N.O.) for indication that torque ramp is complete and current is below 130% motor FLA (End of start).

G. Addition inputs and outputs shall be available to provide the following status indications:
   1. One logic input for force to freewheel, indication of external fault, force to local control, control of cascading motors, or external motor overload reset.
   2. One logic output for indication of motor thermal overload pre-alarm or presence of motor current and one logic output to indicate overcurrent alarm.
   3. One analog output shall be available for 4 – 20 or 0 – 20 milliamp indication of motor current, torque, thermal state or power factor.

H. Relay and I/O functions listed above must be isolated with respect to common.

2.5 PROTECTION

A. A microprocessor controlled thermal protection system shall be included which continuously calculates the temperature-rise of the motor and soft start and provides:
   1. An overload pre-alarm which indicates by relay contact that the motor has exceeded its rated temperature rise by 110%. This function shall be annunciation only.
   2. A thermal fault condition which stops the motor if the temperature-rise exceeds 120% of the motor thermal capability.
   3. An analog electronic circuit with a time constant adjustable to the motor's thermal cooling time constant ensuring the memorization of the thermal state even after power supply disconnection or shorting out of the power semiconductors.

B. The soft start shall provide phase loss, phase reversal, underload, stall, and jam protection.

C. The integral protective features shall be active even if an external shorting contactor is used to bypass the SCRs during steady state operation.

2.6 CONTROL OPTIONS

A. The soft start's control circuit shall be fed from the line supply and be completely independent of the power circuit and separate from the control logic.

B. The peripheral soft start control circuitry shall be operated at 120 Vac 60 Hz from a control power transformer included within the enclosure.

C. Operator devices shall be door mounted and shall be (choose all that apply):
   1. Red STOP and green START push buttons.
   2. Four position L-O-R-A switch which provides for manual (local) start or remote start from pushbuttons at the pump, or automatic start from a PLC based on a control sequence.
   3. Red or Green RUN pilot light illuminated whenever the soft start is provided a run command and no fault condition is present.
   4. Red or Green OFF pilot light illuminated whenever the soft start is supplied with control power and no run command is present.
   5. Three position H-O-A switch which provides for manual (HAND) start or remote signal (AUTO) start from user supplied relay contacts.
   6. (Available with reversing starter only) Red STOP, green FORWARD and amber REVERSE push buttons mounted on the door control island.

D. All operator devices shall be remote mounted using supplied 120 Vac control logic. Clearly labeled terminals shall be provided for field installation.

E. Set up the SMC with the pump option to ramp the motor down on shutdown.

2.7 SHORTING CONTACTOR

A. A microprocessor shall control the operation of the shorting contactor via an output relay.

B. The shorting contactor shall close, shorting the thyristors after the motor current is below 130% of motor FLA and voltage is below nominal voltage (indicating ramp complete) and open on a stop command to allow deceleration ramp.

C. Overload protection integral to the soft starter shall continue to protect the motor when shorting is utilized.

2.8 MISCELLANEOUS

A. Additional devices to be furnished and installed in the solid state motor starter shall be as specified herein and as shown on the control schematic provided in the Contract Drawings.

B. Only the main feeder to the starter shall be provided. No auxiliary control power service will be provided. The manufacturer therefore is required to provide a properly sized fused control circuit transformer to provide control voltage (120 volts maximum).

C. An isolating contactor is required to totally disconnect the starter from the power supply when not operating. Auxiliary relays shall be furnished as necessary to accomplish the necessary control functions as shown on the Contract Drawings.

D. A voltmeter shall be provided on the door, along with a selector switch for monitoring all phase voltages.

E. The manufacturer shall determine whether a bypass contactor is needed based on size of load or starter enclosure type or both, and provide same as part of the lump sum bid. If a bypass contactor is used, it shall be prewired as part of the package, complete with a timer and any auxiliary relays required. All starter protective functions outlined herein shall continue to function while the bypass contactor is energized.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Solid-state motor starters shall be treated as specified in General and Special Conditions.

3.2 INSTALLATION/APPLICATION/ERECTION

A. Installation shall comply with applicable codes and manufacturer's recommendations and instructions.

B. All freestanding cabinets shall be anchored to their foundation.

3.3 FIELD PAINTING

A. On separately mounted starters, field painting shall be limited to touch-up. Manufacturer standard paint is acceptable.

B. On starters mounted on the driven equipment, provided as a package, the starters shall be factory painted to match equipment. Field painting shall be limited to touch-up.

3.4 START-UP AND TRAINING

A. The manufacturer shall furnish the services of a factory technician to assist the Contractor in installation as required and the factory technician shall perform all adjustments and setup prior to operation. The settings shall be performed at the same time the driven equipment start-up personnel are on site to be sure all items operate well together. Furnish a written report to the Engineer on this start-up.

B. The start-up personnel from the factory shall provide Owner personnel with training as outlined in Section 16050.

3.5 TOOLS AND SPARE PARTS

A. Any special tools needed by the Owner for the future maintenance shall be provided.

B. Ten (10) spare control power fuses shall be provided for each size/type used in this equipment.

C. One spare set of 3 SCR fuses for each size used.

D. One (1) spare control circuit transformer of each type/size used shall be provided.

E. One (1) complete set of spare SCR assemblies (for all 3 phases) shall be provided for each size of starter.

+ + END OF SECTION + +

SECTION 16446

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 REFERENCES

A. The drive shall be designed to meet the following specifications:
   1. NFPA 70 - US National Electrical Code
   2. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems
   3. NEMA 250 - Enclosures for Electrical Equipment
   4. UL 508C – Underwriter's Laboratory
   5. CAN/CSA-C22 No. 14-M91 - Canadian Standards Association
   6. IEC 146 - International Electrical Code
   7. IEEE 519-1992 – Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

1.2 REGULATORY REQUIREMENTS

A. The drive shall conform to the following requirements:
   1. FPA 70
   2. IEC 146
   3. EN Standard/CE marked for EMC directives

Emissions	Immunity
EN 50081-1	EN 50082-1
EN 50081-2	EN 50082-2
EN 55011 Class A	IEC 801-1,2,3,4,6,8
EN 55011 Class B	(per EN 50082-1,2)

   4. EN Standard/CE marked for Low Voltage directives
      EN 60204-1
      PREN 50178
   5. IEC 801
   6. C-UL marking to provide an approved listing for both United States and Canadian users.
   7. The Manufacturer will furnish the product as listed and classified by Underwriter's Laboratories.
   8. The product shall perform under the limits of IEEE 519 at the point of commonn coupling as defined in this specification.

1.3 QUALIFICATIONS

A. Manufacturer: The drive manufacturer shall have been in the drive business

continuously for a minimum of 15 years and specialize in the design and manufacturing of PWM Adjustable Frequency Drives.

B. Support: The drive manufacturer shall maintain factory trained and authorized service facilities for their drives within 100 miles of the project and have a demonstrated record of service for at least the previous three years. Full-time support personnel shall be employed by the drive manufacturer.

C. Certification: All drives must be assembled at locations that are certified to the ISO-9001 Series of Quality Standards. This insures all quality and corrective action procedures are documented and implemented with a goal of Total Customer Satisfaction.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. "Allen Bradley."

B. No substitutions.

2.2 RATINGS

A. Input Power: The drive is self adjustable to accept an input voltage range between 200-240/380-480/500-600VAC, three phase +/-10%.

B. Displacement power factor shall range between 1.0 and 0.95, lagging, over the entire speed range (0.80 for 0.5-5hp/0.37-3.7kW, 200-480V drives). The efficiency of the drive shall be a minimum of 97% at full load and speed.

C. Environment: Storage ambient temperature range: -40 to 70 C (-40 to 158 F). Operating ambient temperature range: 0 to 40 C (0 to 109 F) without derating. The relative humidity range is 5% to 95% non-condensing.
   1. Operating elevation: up to 1000 Meters (3,300ft) without derating.

D. Output Power: The output voltage is adjustable from 0 to rated input voltage. The output frequency range is adjustable from 0 to 400 Hz. The inverter section will produce a pulse width modulated (PWM) waveform using latest generation IGBTs.

E. VFD shall be housed in painted steel NEMA 12 enclosure in compliance with Section 13430, Control Panels and Enclosures.

2.3 DESIGN

A. Hardware: The drive hardware shall employ the following power components:

1. Diode or fully gated bridge on the input.
2. DC bus inductor on all ratings 5.5kW (7.5HP) or greater.
3. Switching logic power supply operating from the DC bus.
4. Phase to phase and phase to ground MOV protection.
5. Gold plated plug-in connections on printed circuit boards.
6. Microprocessor based inverter logic isolated from power circuits.
7. Latest generation IGBT inverter section.
8. Inverter section shall not require commutation capacitors.
9. Customer Interface common for all horsepower ratings. Interface shall include an LCD digital display, programming keypad and operator keys option.
10. Main Control Board common for 5.5kW (7.5HP) and up.
11. Common control connection for all ratings.
12. Optimized for 4kHz carrier frequency at 44kW (60HP) or less, and 2kHz at 55kW (75 HP) and larger.
13. Peripheral Interface to enable attaching common options.
14. Input line reactors to limit harmonics intorduced to the power system to meet or exceed IEEE 519 limits at the point of common coupling defined in this specification.
15. Output line reactors to limit motor voltage spikes to less than MG1 motor limits.

B. Control Logic: The drive shall be programmable or self adjusting for operation under the following conditions:
   1. Operate drive with motor disconnected.
   2. Controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit and annunciation of the fault condition.
   3. Adjustable PWM carrier frequency within a range of 2-8kHz.
   4. Selectable Sensorless Vector or V/Hz mode.
   5. Selectable for variable or constant torque loads. Selection of variable torque provides 115% of rated VT current for up to one minute. Selection of constant torque provides 150% of rated CT current for up to one minute.
   6. Multiple programmable stop modes including - Ramp, Coast, DC-Brake, Ramp-to-Hold and S-curve.
   7. Multiple acceleration and deceleration rates.
   8. Multiple acceleration and deceleration rates.
   9. All adjustments to be made with the door closed.
   10. Adjustable output frequency up to 400Hz.

C. POWER CONDITIONING: The drive shall be designed to operate on an AC line which may contain line notching and up to 10% harmonic distortion. An input isolation transformer shall not be required for protection from normal line transients.

2.4 FEATURES

A. Interface: The drive shall provide a removable Human Interface Module with integral display to show drive operating conditions, adjustments and fault indications. The display shall be removable under power without causing a fault and is visible and operable without opening the enclosure door. The display shall consist of 2 lines of 16 character alphanumeric, backlit LCD with the display being configurable for simultaneously displaying two values using customized multi-lingual text and user scaled units. The module shall provide LED indication of drive direction and commanded direction. The display shall be capable of remote mounting by means of cable connection up to 10 meters (33ft) from the drive and is capable of being used as a hand-held terminal.

B. Control Mode: Programming shall provide the ability to select sensorless vector or v/hz mode. The sensorless vector mode shall use motor nameplate data plus motor operating data, such as IR drop, nominal flux current and flux up time. The volts per hertz mode shall be able to be programmed for squared, cubed, straight line, pre programmed or full custom patterns.

C. Current Limit: Programmable current limit shall be available from 20% to 160% of constant torque rating. Current limit shall be active for all drive states; accelerating, constant speed and decelerating. The drive shall employ PI regulation with an adjustable gain for smooth transition in and out of current limit.

D. Acceleration/Deceleration: Accel/Decel settings shall provide separate adjustments to allow either setting to be adjusted from 0 seconds to 3600 seconds. A second set of remotely selectable Accel/Decel settings shall be accessible with Control Interface option. An adaptive current limit circuit shall be able to be disabled in programming for fast acceleration of low inertia loads.

E. Speed Regulation: The programmable speed regulation modes shall include the following:
   1. Open Loop
   2. Slip Compensation with 0.5% speed regulation
   3. Droop - Negative Slip Compensation with 0.5% speed regulation
   4. Traverse Function
   5. Closed loop encoder feedback with 0.1% speed regulation
   6. Process PI control

F. Speed Profiles: Programming capability shall allow the user to produce speed profiles with linear acceleration/deceleration or "S-Curve" profiles that provide changing accel/decel rates. S-Curve profiles shall be selectable for fixed or adjustable values.

G. Adjustments: The digital interface shall be provided for all set-up, operation and adjustment settings. All adjustments are shall be stored in nonvolatile memory (EEPROM). Potentiometer adjustments are not acceptable. The drive shall provide EEPROM memory for factory default values.

H. Process PI Control: An internal process PI regulator shall have both proportional and integral gain adjustments as well as error inversion and output clamping functions. The feedback may be configured for normal or square root functions. If the feedback indicates that the process is moving away from the setpoint, the regulator will adjust the drive output until the feedback equals the reference. Process control shall be enabled or disabled with a hardwire input. Transitioning in and out of process control shall be able to be tuned for faster response by preloading the integrator. Protection shall be provided for a loss of feedback or reference signal.

I. Fault Reset/Run: The drive shall have the ability to conduct up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart. The automatic mode is not applicable to a ground fault, shorted output faults and other internal microprocessor faults. The time between restarts shall be adjustable from 0.5 seconds to 30 seconds.

J. Skip Frequencies: The drive shall contain three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance. The set points shall have a bandwidth adjustable from 0Hz to 15Hz.

K. Run On Power Up: A user programmable restart function shall be provided to automatically restart the equipment after restoration of power after an outage. A maintained 2-wire start input is required for this function.

L. Line Loss Restart: This programmable function shall be provided to select the reconnect mode of the drive after recovery from a line loss condition. The reconnect modes shall be B Last Speed, Speed Search, Track Volts, or Use Encoder. Disabling this feature shall force the drive to start from zero hertz.

M. Fault Memory: The last four faults as well as operating frequency, drive status and power mode shall be stored at the time of fault. Information shall be maintained in the event of a power loss.

N. Overload Protection: The drive shall provide Class 20 motor overload protection investigated by UL to comply with N.E.C. Article 430. Overload protection shall be speed sensitive and adjustable for motors with speed ranges of 2:1, 4:1 and 10:1. A viewable parameter shall store the overload usage in percent. An alarm bit can be used to adjust a process to eliminate an overload trip.

O. Auto Economizer: This feature shall automatically reduce the output voltage when the drive is operating in an idle mode (drive output current less than programmed motor FLA). The voltage shall be reduced to minimize flux current in a lightly loaded motor thus reducing kW usage. If the load increases, the drive shall automatically return to normal operation.

P. Terminal Blocks: Separate terminal blocks shall be provided for control and power wiring.

Q. Flying Start: The drive is shall be capable of determining the speed and direction of a spinning motor and adjust its output to "pick-up" the motor at the rotating speed. The flying start feature shall be operable with or without encoder feedback.

R. Ride Through: The control logic shall be capable of "riding through" a power outage of up to 2 seconds in duration.

S. Analog Output: An output signal shall be provided and be jumper selectable for 0 - 10V DC or 0 - 20 mA which is user programmable such that it is proportional to one of 13 process parameters including output frequency, output current, encoder feedback, output power and others. A programmable offset shall be provided to allow modification of the analog output to obtain 2 - 10V DC or 4 - 20 mA. Programmable gain adjustments for both upper and lower settings shall allow for system calibration.

T. Reference Signals: The drive shall be capable of the following input reference signals:

Digital pulse input	Digital MOP
Remote potentiometer	Serial
10V DC	HIM (Program/Control panel)
20 Ma	

U. Loss of Reference: In the event of loss of the 4 - 20 mA reference signal, the drive shall be user programmable to the following:

Fault and stop
Alarm and maintain last reference within 10%
Alarm and go to preset speed
Alarm and go to minimum speed
Alarm and go to maximum speed
Active for Process PI reference or feedback

V. Digital I/O: Contact output ratings shall be 115V AC/30V DC, 5.0 Amp resistive, 2.0 Amp inductive.

W. Output Line Reactor: Provide output line reactor sized per the motor horsepower.

X. Input line reactor: Provide an input line reactor sized such that the VFD, operating at 1000% speed and at the load provided by the driven equipment will not exceed IEEE 519 limits at the point of common coupling.
   1. The point of common coupling shall be defined as the main circuit breaker or lugs of the first power distribution point that the VFD is connected. That will be the motor control center, switchgear or pannelboard.
   2. I_{FL} shall be defined as the full load as imposed by the driven equipment that the VFD is attached.

3. I_{SC} shall be defined as that value provided by 16490 – Electrical Power System Studies.

Y. Specific features and functional description for each VFD shall be as shown on the Contract Drawings and specified in the following Specification Sections:
   1. GAC Feed Pumps VFD (qty. 3), Section 11110, Vertical Line Shaft Pumps.
   2. Rapid Mixer VFD (qty. 2), Section 11221, Vertical Turbine Flocculation Equipment.
   3. Flocculation Mixer VFD (qty. 4), Section 11242, Mechanical Flash Mixers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anchor all cabinetry firmly to the foundation.

B. Comply with manufacturer's recommendations, except as modified herein.

C. Drives shall be adjusted such that maximum speed is motor nameplate RPM, and minimum speed is just high enough to provided motor driven equipment cooling. Coordinate with driven equipment manufacturer's recommendations.

3.2 START-UP, TRAINING, AND TESTING

A. The drive manufacturer shall provided factory authorized, trained service personnel for start-up and testing. Upon successful completion of installation and testing, training shall be provided in accordance with 16050.

3.3 TOOLS AND SPARE PARTS

A. Any special tools required for normal operation and maintenance shall be provided by the equipment manufacturer.

B. Furnish the following spare parts:
   1. Ten fuses for each type used.
   2. Ten lamps for each type used.

+ + END OF SECTION + +

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SECTION 16455

CABLE TRAY

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish and install cable tray systems complete, of straight sections, fittings, and accessories as defined in the latest NEMA standards publication VE-1.

B. The general rating of trays shall be as shown on the Contract Drawings.

C. Cable tray provided shall be UL listed as suitable as an equipment grounding conductor.

1.2 RELATED WORK

A. Special requirements for materials and equipment are given in Division 0 and 1.

B. Special sequence or schedule requirements are found in the Summary of Work.

1.3 QUALIFICATIONS

A. These materials shall be furnished by a single manufacturer who is experienced, reputable, and qualified in the manufacture of cable trays. It shall be manufactured by Square D, B-Line, or equal.

1.4 SUBMITTALS

A. Shop drawings and other items needed to establish compliance with the Contract Drawings and these Specifications shall be submitted to the Engineer in accordance with Project General and/or special Conditions. As a minimum, submittals shall include descriptive literature, dimensions, weights, layout drawings, materials of construction, NEMA load class, rung spacing, depth, and shall include accessories/fittings.

1.5 WARRANTY

A. These materials shall be warranted for one year concurrent with the Contractor provided warranty.

PART 2 - PRODUCTS

2.1 MATERIALS AND FINISHES

A. Straight section and fitting side rails and rungs shall be extruded from Aluminum Association Alloy 6063. Fabricated parts shall be made from Alloy 5052.

2.2 TRAY TYPES

A. Ladder

1. Ladder type trays shall consist of two longitudinal members (side rails) with transverse members (rungs) welded to the side rails. Rungs shall be spaced 6 inches on center. Rung spacing in radiused fittings shall be measured at the center of the tray's width. Rungs shall have a minimum cable bearing surface of 7/8" with radiused edges. No portion of the rungs shall protrude below the bottom plane of the side rails.

2.3 TRAY SIZE

A. Trays shall have an overall nominal depth of 5 inches with a minimum usable loading depth of 4 inches.

B. Straight sections side rails shall be I-beam, C rail or Z rails. All straight sections shall be supplied in standard lengths of 12 feet.

C. Widths shall be as shown on the Drawings.

D. Fitting radius shall be 12. Side rails of straight sections and fittings shall be compatible so that standard splice plates can be used to join straight sections and fittings. Fittings shall have 3" tangents beyond the curved section to accommodate the standard splice plates.

2.4 SPLICE PLATES

A. Splice plates shall be the bolted type, using either square neck or ribbed-neck carriage bolts and serrated flange lock nuts. The resistance of fixed splice connections between an adjacent section of tray shall not exceed 0.00033 ohm. The cable tray shall be designed so that a splice plate located anywhere along the span shall not decrease the strength of the cable tray system.

B. Splice plates shall be furnished with straight sections and fittings.

2.5 ACCESSORIES

A. Covers and other special accessories shall be furnished as required to protect, support, and install the cable tray system.

2.6 LOADING CAPACITIES

A. Cable tray shall be installed to meet NEMA class descriptions for a safety factor of 1.5.

B. Cable tray shall be made to manufacturing tolerances as specified by NEMA.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Cable tray and accessories shall be treated as specified in General and Special Conditions.

3.2 INSTALLATION/APPLICATION/ERECTION

A. Installation shall comply with applicable codes and manufacturer recommendations and instructions.

B. All trapezes, hangers, and supports shall be provided as required, by the Contractor, and materials shall be compatible and similar to the tray furnished.

C. Finish and install necessary restraints and sway bracing to comply with KBC requirements for applicable seismic zone.

3.3 FIELD PAINTING

A. Tray shall not be painted generally. Natural finish is acceptable.

+ + END OF SECTION + +

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SECTION 16460

SMALL POWER AND MISCELLANEOUS TRANSFORMERS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Transformer locations and size shall be as shown on the Contract Drawings, as specified herein.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. "Square D", "Eaton", "Siemens", or equal.

2.2 FABRICATION

A. General Purpose Dry-Type Transformers
   1. Three phase transformers shall be 480 volt delta primary and 208 Y/120 or 240 volt delta secondary. Transformers 25 KVA and larger shall have a minimum of 4 (2 above, 2 below) 2-1/2 percent full capacity primary taps.
   2. Transformers shall be 150 degrees Celsius temperature rise above a 40 degrees Celsius ambient. All insulating materials are to be in accordance with the latest NEMA Standards for a 220 degrees Celsius UL recognized insulation system.
   3. Transformer coils shall be of the continuous wire wound construction and shall be impregnated with non-hygroscopic, thermo-setting varnish. The coils shall also have a final wrap of electrical insulating material to prevent mechanical injury to the wire as well as increasing the electrical breakdown strength.
   4. All cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be clamped together with steel angles. The completed core and coil shall then be bolted to the base of the enclosure but isolated from the base by means of rubber, vibration absorbing mounts. There shall be no metal-to-metal contact between the core and coil to the enclosure. On transformers 500 KVA and smaller, the vibration isolation system shall be designed to provide a permanent fastening of the core and coil to the enclosure. To further facilitate vibration and noise isolation, the final section of conduit to the transformer shall be flexible.
   5. Transformers 25 KVA and larger shall be in heavy gauge, sheet steel, ventilated enclosures. The ventilating openings shall be designed to prevent accidental access to live parts in accordance with UL, NEMA, and National

Electrical Code Standards for ventilated enclosures. Transformers 25 KVA through 75 KVA shall be designed so they can either be floor or wall mounted. Above 75 KVA they shall be of the floor mounted design.

6. The entire transformer enclosure shall be degreased, cleaned, phosphatized, primed, and finished in the same color as the motor control equipment. For more details see Division 9 of these Specifications.
7. The maximum temperature of the top of the enclosure shall not exceed 50 degrees Celsius rise above a 40 degrees Celsius ambient.
8. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with NEMA and NEC Standards.
9. The transformer shall be marked "DANGER HIGH VOLTAGE" with labels specified in the section on marking, this Division.
10. The transformers shall be manufactured to requirements of applicable standards, especially as they apply to noise level and surface temperatures.

PART 3 - EXECUTION

3.1 INSTALLATION / APPLICATION / ERECTION

A. Transformers shall be rigidly mounted to the structure or the foundation in the case of freestanding units.

B. Transformers shall be megger tested prior to energization.

C. Transformers with taps shall be adjusted to supply the nominal service voltage required on the secondary.

D. Transformers shall be installed in accordance with NEC requirements and manufacturer recommendations.

+ + END OF SECTION + +

SECTION 16490

ELECTRICAL POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. The electrical equipment manufacturer shall provide electrical power system studies as specified herein for the entire power system for the project, including existing equipment. The type and content of each study is specified in the following articles.

1.2 SUBMITTALS

A. Study Report
   1. The results of the power system study shall be summarized in a final report. Five bound copies of the final report shall be submitted for review.
   2. The report shall include the following sections:
      a. Description, purpose, basis and scope of the study and a single line diagram of that portion of the power system which is included within the scope of the study.
      b. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties, and commentary regarding same.
      c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse settings, fuse selection, and commentary regarding same.
      d. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The specified electrical power system studies shall be performed by the manufacturer of the power distribution and control equipment furnished for the project.

2.2 ELECTRICAL POWER SYSTEM STUDIES

A. Short-Circuit Analysis
   1. Calculation of the maximum rms symmetrical three-phase short-circuit current at each significant location in the electrical system shall be made using a digital computer.

2. Appropriate motor short-circuit contribution shall be included at the appropriate locations in the system so that the computer calculated values represent the highest short-circuit current the equipment will be subjected to under fault conditions.
3. A tabular computer printout shall be included which lists the calculated short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings, and notes regarding the adequacy or inadequacy of the equipment.
4. The study shall include a computer printout of input circuit data including conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.
5. Include a computer printout identifying the maximum available short-circuit current in rms symmetrical amperes and the X/R ratio of the fault current for each bus/branch calculation.
6. The system one-line diagram shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis.
7. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.
8. The contractor shall be responsible for supplying pertinent electrical system conductor, circuit breaker, generator, and other component and system information in a timely manner to allow the short-circuit analysis to be completed prior to final installation.
9. The interrupting capacity of all over current devices shall equal or exceed the maximum fault current level where they are installed in the system. The system shall be fully rated in that the ability of the device to interrupt a fault at its terminals and shall not depend on the characteristics of an over current device upstream. Series rated devices shall not be acceptable.
10. Any inadequacies shall be called to the attention of the Engineer and recommendations made for improvements as soon as they are identified.

B. Protective Device Time-Current Coordination Analysis
1. The time-current coordination analysis shall be performed with the aid of computer software intended for this purpose, and will include the determination of settings, ratings, or types for the overcurrent protective devices supplied.
2. Where necessary, an appropriate compromise shall be made between system protection and service continuity with service continuity considered more important than system protection.
3. A sufficient number of computer generated log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the

time-current characteristics of series connected overcurrent devices and other pertinent system parameters.

4. Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, the short-circuit current availability at the device location when known, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
5. The study shall include a separate, tabular computer printout containing the suggested device settings of all adjustable overcurrent protective devices, the equipment where the device is located, and the device number corresponding to the device on the system one-line diagram.
6. A computer generated system one-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.
7. A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
8. Significant deficiencies in protection and/or coordination shall be called to the attention of the Engineer and recommendations made for improvements as soon as they are identified.
9. The Contractor shall be responsible for supplying pertinent electrical system conductor, circuit breaker, generator, and other component and system information in a timely manner to allow the time-current analysis to be completed prior to final installation.
10. The Contractor shall be responsible for obtaining ratings of existing overcurrent devices to remain throughout the power system, to include in the coordination study.

C. Arc-Flash Hazard Analysis

1. The Arc-Flash Hazard Analysis shall be performed with the aid of computer software intended for this purpose in order to calculate Arc-Flash Incident Energy (AFIE) levels and [AP1] flash protection boundary distances.
2. The Arc-Flash Hazard Analysis shall be performed in conjunction with a short-circuit analysis and a time-current coordination analysis.
3. Results of the Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment classes and AFIE levels.
4. The analysis shall be performed under worst-case Arc-Flash conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
5. The Arc-Flash Hazard Analysis shall be performed by a registered professional engineer.

6. The Arc-Flash Hazard Analysis shall be performed in compliance with IEEE Standard 1584-2002, the IEEE Guide for Performing Arc-Flash Calculations.
7. The Arc-Flash Hazard Analysis shall include recommendations for reducing AFIE levels and enhancing worker safety.
8. The proposed vendor shall demonstrate experience with Arc-Flash Hazard Analysis by submitting names of at least ten actual Arc-Flash Hazard Analyses it has performed in the past year.
9. The proposed vendor shall demonstrate capabilities in providing equipment, services, and training to reduce Arc-Flash exposure and train workers in accordance with NFPA 70E and other applicable standards.
10. The proposed vendor shall demonstrate experience in providing equipment labels in compliance with NEC-2008 Section 110 and ANSI Z535.4 to identify AFIE and appropriate Personal Protective Equipment classes.

PART 3 – EXECUTION

A. Manufacturer's Field Service: Engage a factory-authorized service representative of electrical distribution equipment being set and adjusted to assist in the setting of overcurrent protective devices within equipment.

B. Overcurrent devices are to be visually inspected to verify that settings determined from the final Over Current Protection Coordination Devices Study have been programmed and/or set.

C. Labels shall be applied to all enclosures, with appropriate site specific Arc Flash warnings, PPE requirements, and boundaries. Boundaries shall be painted on the floor in front of all new switchgear, switchboards, panelboards and MCC's.

D. Upon completion of field setting, provide an updated submittal on all studies updating the changes/revisions.

+ + END OF SECTION + +

SECTION 16495

SWITCHBOARD MATTING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Switchboard matting shall be furnished by the Contractor and placed in front of all power distribution and control equipment.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Switchboard matting shall be W.H. Salisbury & Company, Safety Line, Inc., Tepromark, Wearwell, Erico, or equal.

2.2 MATERIALS

A. Switchboard matting shall be nonconductive with a minimum of 40,000 volts dielectric strength. the mat shall have a corrugated, non-slip surface and shall be a minimum of 1/4 inch thick. Width shall be 36 inches and length shall be as required at each location. The mat shall be black in color, ozone and oil resistant, and manufactured to meet all applicable ANSI/ASTM standards.

PART 3 - EXECUTION

Not Applicable.

+ + END OF SECTION + +

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SECTION 16500

LIGHTING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The specific characteristics of the light fixtures to be furnished and installed shall be as detailed in the Light Fixture Schedule on the Contract Drawings. Should a fixture of a different type or manufacturer than that specified be submitted for the Engineer's review, it will be compared to that specified on: construction, dimensions, and photometrics. Failure to compare equally to what was specified will be grounds for rejection.

B. The Contractor shall be prepared to submit sample equipment for appraisal when requested by the Engineer, and shall assume all transportation costs involved in the shipment and return of samples. All sample fixtures submitted shall be provided with lamps and shall be wired with cord and plug, to facilitate lighting for appraisal.

PART 2 - PRODUCTS

2.1 BALLASTS

A. All ballasts shall have built in resetting thermal protection with external GLR line fuses and be of the high power factor type built to conform to UL and ANSI standards (as attested by CBM certification).

B. Ballasts shall be energy-saving magnetic or electronic, as specified with each fixture type.

C. Note that some fixtures may require two ballasts for two level lighting if indicated in fixture specifications or on drawings.

D. Electrical ballasts shall be non-arcing type.

E. Ballasts shall be as manufactured by Universal Lighting Technologies or approved equal. Universal ballasts shall constitute the type, product quality, material, and desired operation required.

F. All ballasts shall have an independent means of disconnect as required in the latest edition of NFPA 70.

2.2 LUMINAIRES

A. All fixtures shall be delivered complete with suspension and mounting accessories, ballasts, diffusers, reflectors, etc., all wired and assembled. All accessory wiring shall be furnished and installed as shown on the Contract Drawings.

B. All steel supports required for luminaires in addition to that furnished under the general building construction shall be furnished and installed by the Contractor.

C. When fixtures are noted to be installed flush, they shall be complete with the proper accessories for installing in the particular ceiling involved. All flush mounted fixtures shall be supported from the structure and shall not be dependent on the hung ceilings for their support.

D. All outside luminaires shall be a type that will prevent insect accumulation inside the luminaire.

E. Exterior luminaires shall be weatherproof and rustproof.

F. Luminaire wire shall be fixture type of non-asbestos construction.

G. Fluorescent Lamp holders in fixtures utilizing electronic ballasts shall include a lamp locking feature.

2.3 LAMPS

A. Fluorescent lamps shall have 3500K color characteristics unless otherwise indicated, and shall be of the type that will not require starter switches.

B. All lamps shall be as manufactured by General Electric, Osram, Phillips or approved equal.

2.4 LIGHTING CONTACTORS

A. Lighting contactors shall be continuously rated with number of poles as indicated in the Contract Drawings, for all types of ballast and tungsten lighting, resistance and motor loads.

B. The contactor shall have totally enclosed, double-break silver-cadmium-oxide power contacts. Auxiliary arcing contacts are not acceptable. Contact inspection and replacement shall be possible without disturbing line or load wiring. The contactor shall have straight-through wiring and all terminals clearly marked.

C. Contactors shall be UL listed, designed in accordance with pertinent NEMA standards. They shall be industrial-duty rated for applications to 600 volts maximum. Contactor shall have additional accessories as indicated on the Drawings, and shall be NEMA 1 enclosed unless otherwise indicated.

D. Contactor coils shall be continuously rated and encapsulated.

E. Lighting contactors shall have a circuit breaker and contactor mounted in one enclosure. The operator for the circuit breaker shall be externally operated, with door either open or closed. The door shall have an interlock preventing opening unless breaker operator is in off position, with a recessed defeater mechanism for experienced personnel use, and a padlocking attachment.

F. Contactors shall be Square D, General Electric, Westinghouse, or equal.

2.6 PHOTOCELL CONTROLS

A. The photo control shall provide automatic switching for outdoor lighting loads. Control shall be a thermal design with built-in delay to ensure that the controlled lighting does not switch off due to ambient light or lightning striking the photocell. Photo control shall have a rating no less than 1000 VA and 8.3 amps for ballasts based on UL testing at 50% power factor for ballast loads. Photo control shall provide switching for nominal voltage fixtures of 120 volts ± 10% to accommodate fluctuations in supply voltage.

B. Photo control mounting shall be via a surface mount outlet box mounted to backside of parapet wall on roof with all necessary mounting hardware and instructions. Photo control housing shall be constructed of high impact polycarbonate. Photo control shall be 100% factory tested for function within specified light levels.

C. Photo control shall be UL listed. Photo control shall function over temperature range of -40°F (-40°C) to 158°F (70°C). Photo control shall be INTERMATIC Model K4251, or equal.

D. Where specified, a factory furnished and installed photocell shall be provided.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. General
   1. The Contractor shall furnish all light fixtures, lighting equipment, components, hangers, etc., as shown on the Contract Drawings and shall install them at the locations shown on the Contract Drawings.
   2. All fixture wiring shall be in conformance with the latest revision of the NEC and UL standards.
   3. Lamps of the proper type, wattage and voltage rating shall be delivered to the project in the original cartons and installed in the fixtures just prior to the completion of the project, with spare lamps as listed on the Contract Drawings.

4. All lamps used during the building construction in interior contract lighting fixtures prior to 2 weeks from the completion of the work shall be removed and replaced with new lamps.
5. Locations of fixtures shall be coordinated with Engineer's reflected ceiling plans where they exist. Any conflicts between electrical plans and Engineer's reflected ceiling plans, the reflected plans shall override.

B. Luminaires
1. Fixtures shall be rigidly mounted against the surface of the ceiling unless otherwise noted on the Contract Drawings. Conduit runs to and between fixtures shall be rigid metallic type. Use of flexible conduit for connection to fixtures is prohibited, except where concealed above a suspended ceiling.
2. All ferrous metal surfaces of fixtures and plaster frames shall be treated and given rust inhibiting and finish coat adherence properties before final enamel coats are applied. Finish enamel coat shall be baked on at approximately 320° F.
3. Similar fixtures in each room or area shall be installed with bottom of fixtures at same elevation, unless otherwise noted.
4. Minimum wire size shall be AWG No. 10 for runs over 75 feet.
5. Outlets shall be as specified herein and shall be suitable for the installation conditions encountered.
6. Flexible fixture hangers shall be used for all pendant-mounted fixtures.
7. Conduit run in areas with hung ceilings shall be installed in the space above the hung ceiling as close to the structure as possible. Conduits and junction boxes shall be supported from the structure.
8. All ceiling grid mounted fluorescent fixtures shall be installed to fit the actual field layout of the grid system.
9. No light fixtures shall be hung or installed until after painting is completed, however, temporary lighting shall be provided by the Contractor. Fixtures in suspended ceilings shall be fastened to the main tees of the ceiling grid for seismic considerations, although they shall be supported from the building structure.
10. All fixtures shall be left in a clean condition, free of dirt and defects, before acceptance by the Engineer.

C. Lighting Standards
1. All primed area light poles shall be painted per Division 9 of the Specifications. Galvanized steel, weathering steel or aluminum light poles Are Not To Be Painted.
2. When standards (poles) arrive on the job site, the protective wrapping should be removed immediately, especially if stored outside. If not removed, rain or other sources of water moistening the wrapping may cause stains (barber pole effect) on the pole finish. Such stains shall be cause for rejection.

3. A concrete foundation shall be provided for each pole as detailed on the Contract Drawing. The poles will be mounted utilizing anchor bolts set in

the concrete. The anchor bolts should have galvanized or plated threads and should be furnished with the pole by the manufacturer. This is particularly important since they are engineered as part of the pole structural system.

4. When anchor bolts are positioned prior to pouring concrete, spacing and projection must be verified with pole manufacturer's recommendations. A plastic or plywood template should be fabricated from the manufacturer's instructions to use when setting the anchor bolts. Anchor bolts that are not installed plumb and in the correct locations shall be removed and replaced. The Contractor shall not be allowed to bend the anchor bolts back to plumb after concrete is set.
5. Leveling nuts shall be utilized for the mounting of poles to foundations. A nut should be screwed down on each bolt until it meets the concrete, and then the nuts must be adjusted until they are level.
6. The pole should be carefully lowered onto the anchor bolts and allowed to rest on the leveling nuts. Flat washers followed by lock washers should be placed on the anchor bolts and the top nut installed. Minor adjustments on the leveling nuts may be necessary to plumb the pole before the top nuts are tightened down. Special care should be taken to tighten the top nuts to the torque level recommended by the pole manufacturer. All nuts and washers shall be galvanized or plated.
7. Concrete grout of the nonshrink type must be installed between the base of the pole and the concrete foundation. The grout should be puddled around the edge of the pole base and firmly packed in the space between the pole and foundation. A short piece of small diameter pipe must be installed to make a drain hole through the grout to the pole interior.
8. Aluminum poles must have the bottom of the base painted with Koppers bitumastic No. 50 or equal substitute product before grouting so that the aluminum does not come in contact with the concrete.
9. Poles shall not be modified or drilled on the job site.
10. Under no circumstances should a ground wire be wrapped around an anchor bolt underneath an anchor bolt nut.
11. Do not set poles without light fixtures installed, as poles are more likely to vibrate and become damaged.
12. Manufacturer's installation instructions should be followed as well as those instructions contained herein. Should a discrepancy exist, promptly contact the Engineer for clarification.
13. Bases shall have 1" chamfer all around and rubbed smooth to a point below grade.
14. Anchor bolt covers shall also be provided and installed with tamperproof hardware.

+ + END OF SECTION + +

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SECTION 16631

CENTRAL BATTERY INVERTER (IPS) SYSTEMS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Battery inverter system shall transfer loads to the battery inverter source within one second of an outage.

B. Upon normal power failure, switching equipment provided as part of the system shall automatically connect the power source to the emergency system. Upon resumption of normal power, the load shall automatically switch back to the normal source.

C. Units shall be capable of handling HID and fluorescent loads as well as incandescent.

D. The IPS units shall be monitored by Division 17 PLC system to Central Control as for other UPS systems.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Lithonia or equal.

2.2 SYSTEM COMPONENTS

A. Provide single or three phase inverter systems, as indicated on the drawings.

B. Inverter outputs shall be a sine square wave signal, with one normally on and one normally off circuit for each 2,000 volt-amperes of inverter rating.

C. Batteries: Communications grade lead-calcium type with integral hydrometer, and shall supply rated power for 90 minutes, at which time battery output shall be not less than 87% of rated output at 15EC.

D. Battery Charger: Constant voltage type, regulated to plus/minus 0.05 volts, and shall fully recharge the batteries within 24 hours.

E. Monitoring Equipment:
   1. AC Ammeter

2. Battery Ammeter
3. Battery Charge Indicator
4. Battery Voltmeter
5. Electrolyte Level Detector
6. Load Circuit Breaker, AC, for each 2,000 volt-ampere rating or portion thereof
7. Load-on Indicator
8. Power Indicator, AC
9. Remote Low Electrolyte Level Alarm
10. Test Switch
11. Dry contact for on battery to PLC Monitoring System

F. Enclosures: Consisting of one or more steel cabinets, mechanically and electrically interconnected with the following features:
1. Acid-Resistant Paint in manufacturers standard colors
2. Door locks with two keys per door
3. Permanent separation between batteries and electronic components
4. Ventilation louvers

G. Transfer Switches: Solid state or mechanically held, electrically-operated, mounted in a sealed enclosure. An electronically held transfer switch will not be acceptable.

PART 3 - EXECUTION

3.1 GENERAL

A. Anchor all equipment and battery cabinets to their foundation.

B. Install the units in accordance with manufacturer's recommendations.

C. Provide services of factory trained start up personnel to oversee the installation by the Contractor and to assist in commissioning of the units.

D. Provide operation and maintenance training to the Owner on this equipment.

+ + END OF SECTION + +

SECTION 16670

LIGHTNING PROTECTION SYSTEMS (AIR TERMINALS)

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The lightning protection system shall be furnished, installed, and connected as detailed on the Contract Drawings to provide a complete and functional system. Installation and equipment construction shall comply with Lightning Protection Institute Installation Code LPI-175, UL Master Label Code 96A, and NFPA 780.

B. The Contractor shall provide shop drawings indicating location and installation of equipment for review of the Engineer before beginning installation.

C. All equipment shall be of the same manufacturer, insofar as possible.

D. Equipment specified herein supplements actual suppression devices specified in Section 16280.

E. Details provided in the drawings shall supersede this general specification in case of conflict.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. “AC Erico”, “Thompson Lightning Protection, Inc.,” “Independent Protection Co., Inc.,” or equal.

2.2 EQUIPMENT

A. All equipment used in this installation shall be UL approved and labeled in accordance with UL procedures, with each air terminal bearing an “A” label and all main conductors bearing a “B” label at 10'-0" intervals.

B. All equipment shall be new, and of design and construction to suit the application where it is used in accordance with accepted industry standards and LPI and UL code requirements and as per manufacturers recommendations.

C. Downlead conductors from roof to ground shall be copper of 28 strands, 17 gauge minimum. All main roof conductors shall be aluminum of 24 strands, 14 gauge minimum.

D. Air terminals shall be solid, round aluminum bar of 1/2” minimum diameter, and shall project 10" minimum above the object to be protected.

E. Air terminal bases shall be of cast aluminum with bolted pressure cable connections and shall be securely mounted with stainless steel screws or bolts. Bases on built-up tar and gravel roofs shall be secured with a proper adhesive and shall have a minimum surface contact area of 18.5 square inches.

F. Ground rods shall be a minimum of 3/4" in diameter and 10'-0" long. They shall be connected to the system using exothermic welds, Cadweld, or equal.

G. Cable fasteners shall be substantial in construction, electrolytically compatible with the conductor and mounting surface and shall be spaced according to LPI and UL code requirements.

H. Bonding devices, cable splicers and miscellaneous connectors shall be of cast aluminum with bolted pressure connections to cable. Cast or stamped crip fittings are not acceptable.

I. Equipment on stacks and chimneys shall be protected from corrosion and sized in accordance with LPI and UL requirements.

J. All miscellaneous bolts, nuts, and screws shall be stainless steel.

K. An approved bimetal transition fitting shall be used at the roof level to change from aluminum roof conductor to copper downlead cable.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. The installation shall be accomplished by an experienced installer listed with Underwriters’ Laboratories as qualified and who is also a Certified Master Installer of the LPI or working under the direct supervision of an LPI manufacturer as listed above or his authorized LPI Certified Master Installer representative.

B. All equipment shall be installed in a neat workmanlike manner in the most inconspicuous manner possible. The system shall consist of a complete cable network on the roof including all air terminals, splices, and bonds with cable downleads routed concealed either directly in the building construction for a new structure or in conduit to ground for an existing structure.

C. The copper downlead cables shall not be brought directly through the roof. Through roof connectors with solid rods or conduits though pitch pockets shall be utilized for this purpose.

D. The limitations on areas of usage for aluminum cables and for copper and aluminum materials together as outlined in UL 96A and LPI 175 shall be observed. The lightning protection installer will work with other trades to ensure a correct, neat, and unobtrusive installation.

E. It shall be the responsibility of the lightning protection installer to assure a sound bond to the metallic main water service and to assure interconnection with other building ground systems, including both telephone and electrical and also to ensure that proper arresters have been installed on the power service.

F. Downlead conductors from roof to ground shall be protected from mechanical damage from a point 8 feet above to 1 foot below grade by conduit or other means.

G. The lightning protection installer shall secure and deliver a UL Master Label and LPI System Certification to the Engineer for the Owner for each structure upon completion of the installation.

H. The Contractor shall also submit 2 copies of as built shop drawings, 1 with the UL Master Label Application Form and another with LPI forms 175A and B.

I. A permanent plate shall be affixed to each protected structure in a prominent location, indicating its UL approval, using tamper proof security fasteners.

+ + END OF SECTION + +

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SECTION 16715

FIBER OPTIC DATA TRANSMISSION SYSTEM

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. General: A fiber optics (FO) data transmission system (DTS) shall be provided. The data transmission system shall consist of fiber optic transmission media. The data transmission system shall interconnect system components as shown on the Drawings.

B. Environmental Requirements: Equipment and cable to be utilized indoors shall be rated for continuous operation under ambient environmental conditions of 0 to 50 degrees C (35 to 120 degrees F) dry bulb and 10 to 95 percent relative humidity, noncondensing. Equipment shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location. Fiber optic cable for outdoor installation shall be rated for minus 40 to plus 122 degrees F.

C. Electrical Requirements: The equipment shall operate from a voltage source as shown, plus or minus 10 percent, and 60 Hz, plus or minus 2 percent.

D. Input Line Surge Protection: Inputs and outputs shall be protected against surges induced on wiring including wiring installed outdoors. Communications equipment shall be protected against surges induced on any communications circuit. Cables and conductors (except fiber optics which serve as communications circuits from consoles to field equipment) and between field equipment, shall have surge protection circuits installed at each end. Protection shall be furnished at equipment, and additional triple electrode gas surge protectors rated for the application on each wire line circuit shall be installed within 1 meter 3 feet of the building cable entrance. Fuses shall not be used for surge protection. The inputs and outputs shall be tested in both normal mode and common mode using the following two waveforms:
   1. A 10 microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
   2. An 8 microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

E. Power Line Surge Protection: Equipment connected to ac circuits shall be protected from power line surges. Equipment shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

1.2 SUBMITTALS

A. Submittals
   1. System Drawings: The package shall include the following:
      a. Communications system block diagram.
      b. Details of system interfaces.
      c. Details of connections to power sources, including grounding.
      d. Details of surge protection device installations.
      e. Details of cable splicing and connector installations.
      f. Details of underground cable installation, cable entrance into buildings, and terminations inside enclosures.
   2. Equipment Data: A complete data package shall be delivered for all material, including field and system equipment.
   3. Certifications: Specified manufacturer's certifications shall be included with the data package.
   4. Hardware Manual: A manual describing equipment furnished, including:
      a. General description and specifications.
      b. Installation and checkout procedures.
      c. Equipment electrical schematics and layout drawings.
      d. Data transmission systems schematics.
      e. Alignment and calibration procedures.
      f. Manufacturer's repair parts list indicating sources of supply.
      g. Interface definition.
   5. Operator's Manual: The operator's manual shall fully explain procedures and instructions for operation of the system.
   6. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

PART 2 - PRODUCTS

2.1 ENCLOSURES

A. Enclosures shall conform to the requirements of NEMA 250 for the types specified. Finish color shall be the manufacturer's standard, unless otherwise indicated. Damaged surfaces shall be repaired and refinished using original type finish.
   1. Interior: Enclosures installed indoors shall meet the requirements of Type 12 or as shown.
   2. Exterior: Enclosures installed outdoors shall meet the requirements of Type 4X.

B. Equipment Rack (for GAC Feed Pump Bldg.):
   1. General:
      a. Provide a nameplate for the enclosures in compliance with Section 16075, Electrical Identification.

b. Rails shall be pre-tapped and drilled for their full height per EIA standards.

2. Enclosed Wall Mount Rack
   a. Size shall be as required to house all equipment plus 20% spare rack space (units).
   b. Enclosure shall be double-hinged to allow access to the back of mounted equipment.
   c. Side rails for full height for equipment attachment.
   d. Top, bottom and side panels shall be solid.
   e. Window frame front door with key latch and two keys (keys shall operate both front and rear doors).
   f. Back hinge shall be lockable in the closed position to limit rear access.
3. Accessories:
   a. 6 outlet rack mount power strip with 15 foot cord and plug.
   b. One fixed vented equipment shelf.
   c. Surge Protection Device.
4. Product and Manufacturer: Provide one of the following:
   a. Hoffman.
   b. Hergo
   c. APW Zero Stantron.
   d. Or equal.

2.2 FIBER OPTIC PATCH PANELS

A. Provide fiber optic cable patch panels as referenced on the drawings and which meet the following requirements:
   1. Furnish panels with the following accessories:
      a. Trays.
      b. Cable strain relief.
      c. Bend radius protectors.
      d. Routing guides.
      e. Grommetted cable entries.
      f. SC simplex adapters and adapter plates.
      g. Sufficient working space for removal of connectors.
      h. Identification label.
      i. All cable management hardware required to accomplish the installation.
   2. It is acceptable for the accessories to be installed in a separate enclosure inside the one large enclosure.
   3. Furnish each cabinet with a keylock and two (2) keys. All cabinets provided are to be keyed alike so that a single key opens all cabinets.
   4. Furnish cabinets with internal space to store, organize, and strain relieve incoming and outgoing cables.
   5. Ground lug for cable support member and routing supports to maintain allowable cable bend radius.

6. Where the required number of terminations exceed the capacity of a single patch panel, multiple patch panels shall be provided. These multiple patch panels shall be enclosed in a single enclosure.

2.3 FIBER OPTIC CONNECTORS

A. FO connectors shall be the straight tip, bayonet style, field installable, self-aligning and centering. FO connectors shall match the fiber core and cladding diameters. The connector coupler shall be stainless steel and the alignment ferrule shall be ceramic. FO equipment and cable shall use the same type connectors. Connector insertion loss shall be nominally 0.3 dB and less than 0.7 dB.

B. FO connectors shall be type SC, unless otherwise required to match equipment type provided.

C. Prior to installed FO connector, install suitable fan-out kit.

2.4 SYSTEM REQUIREMENTS

A. Signal Transmission Format Code
   1. FO equipment shall use the same transmission code format from the beginning of a circuit to the end of that circuit. Different transmission code formats may be used for different circuits as required to interconnect supported equipment.

B. Flux Budget/Gain Margin
   1. FO links shall have a minimum gain margin of 6 dB. The flux budget is the difference between the transmitter output power and the receiver input power required for signal discrimination when both are expressed in dBm. The flux budget shall be equal to the sum of losses (such as insertion losses, connector and splice losses, and transmission losses) plus the gain margin. When a repeater or other signal regenerating device is inserted to extend the length of an FO circuit, both the circuit between the transmitter and the repeater-receiver, and the circuit between the repeater-transmitter and the receiver are considered independent FO links for gain margin calculations.

C. Receiver Dynamic Range
   1. The dynamic range of receivers shall be large enough to accommodate both the worst-case, minimum receiver flux density and the maximum possible, receiver flux density. The receiver dynamic range shall be at least 15 dB. Where required, optical attenuators shall be used to force the FO link power to fall within the receiver dynamic range.

2.8 OPTICAL FIBERS

A. General

1. Optical fibers shall be coated with a suitable material to preserve the intrinsic strength of the glass. The outside diameter of the glass-cladded fiber shall be nominally 125 microns, and shall be concentric with the fiber core. Optical fibers shall meet EIA 455-46A, EIA 455-65, and EIA 455C177A.

B. 62.5 Micron Multimode Fibers

1. Conductors shall be multimode, graded index, solid glass waveguides with a nominal core diameter of 62.5 microns. The fiber shall have transmission windows centered at 850 and 1330 nanometer wavelengths. The numerical aperture for each fiber shall be a minimum of 0.275. The attenuation at 850 nanometers shall be 4.0 dB/Km or less. The attenuation at 1330 nanometers shall be 1.5 dB/Km or less. The minimum bandwidth shall be 160 MHZ-Km at 850 nanometers and 400 MJ-Iz-Km at A300 nanometers. FO cable shall be certified to meet EIA 455-30B and EIA 455-58A.

2.9 CABLE CONSTRUCTION

A. General

1. The cable shall contain a minimum of two fiber optic conductors for each full duplex circuit. The number of fibers in each cable shall be as shown. Each fiber shall be protected by a protective tube. Cables shall have a jacketed strength member, and an exterior jacket. Cable and fiber protective covering shall be free from holes, splits, blisters, and other imperfections. The covering shall be flame retardant, moisture resistant, non-nutrient to fungus, ultraviolet light resistant as specified and nontoxic. Mechanical stress present in cable shall not be transmitted to the optical fibers. Strength members shall be non-metallic and shall be an integral part of the cable construction. The combined strength of all the strength members shall be sufficient to support the stress of installation and to protect the cable in service. The exterior cables shall have a minimum storage temperature range of minus 20 to plus 75 degrees C. (minus 40 to plus 167 degrees F). Interior cables shall have a minimum storage temperature of minus 10 to plus 75 degrees C. (plus 14 to plus 167 degrees F). All cables furnished shall meet the requirement of NFPA 70. Fire resistant characteristics of cables shall conform to Article 770, Sections 49, 50, and 51. A flooding compound shall be applied into the interior of the fiber tubes, into the interstitial spaces between the tubes, to the core covering, and between the core covering and jacket of all cable to be installed aerially, underground, and in locations susceptible to moisture. Flooded cables shall comply with EIA 455-81A and EIA 455-82B. Cables shall be from the same manufacturer, of the same cable type, and of the same size. Each fiber and protective coverings shall be continuous with no factory splices. Fiber optic cable assemblies, including jacketing and fibers, shall be certified by the manufacturer to have a minimum life of 30 years. Plenum cable shall meet UL 910, and riser cable shall meet UL 1666. FO cable shall be certified to meet the following: EIA 455C13, EIA 455C25A, EIA 455C41, EIA 455C47B, EIA 455C59,

EIA 455C61, EIA 455C88, EIA 455C91, EIA 455C104A, and EIA 455C171.

B. Exterior Cable
   1. Duct Cable
      a. The optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement.
         1) The cable outer jacket shall be medium density polyethylene material with orange pigment added for ease of identification.
         2) Tensile strength: Cables shall withstand an installation tensile load of not less than 2700 Newtons (608 pounds) and not less than 600 Newtons (135 pounds) continuous tensile load.
         3) Impact and Crush resistance: The cables shall withstand an impact of 3 Newton-meters (l.7 lbs/in) as a minimum, and shall have a crush resistance of 220 Newtons per square centimeter (317 pounds per square inch) as a minimum.

C. Pigtail Cables
   1. Cable used for connections to equipment shall be flexible fiber pigtail cables having the same physical and operational characteristics as the parent cable. The cable jacket shall be flame retardant PVC or FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cable shall be 3.5 dB/km at 850 nanometers, and 1.0 db/km at 1330 nanometers.

2.10 MECHANICAL SPLICES

A. Mechanical splices shall be suitable for installation in fiber optic patch panels. External power sources shall not be required to complete a splice. Splices shall be self-aligning for optimum signal coupling. Mechanical splices shall not be used for exterior applications where they may be buried underground or laced to aerial messenger cables. Mechanical splices may be used for interior locations and within enclosures. Splice closures shall protect the spliced fibers from moisture and shall prevent physical damage.

B. The splice closure shall provide strain relief for the cable and the fibers at the splice points.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

System components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown. Interconnections, services, and adjustments required for a complete and operable data transmission system shall be provided.

A. Interior Work: Cable installation and applications shall meet the requirements of NFPA 70, Article 770, Sections 52 and 53. Cables not installed in conduits or wireways shall be properly secured and neat in appearance, and if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.

B. Exterior Underground Cable
   1. For cables installed in ducts and conduit, a cable lubricant compatible with the cable sheathing material shall be used on all cables pulled. Pulling fixtures shall be attached to the cable strength members.
   2. If indirect attachments are used, the grip diameter and length shall be matched to the cable diameter and characteristics. If an indirect attachment is used on cables having only central strength members, the pulling forces shall be reduced to ensure that the fibers are not damaged from forces being transmitted to the strength member. During pulling the cable pull line tension shall be continuously monitored using dynamometers or load-cell instruments, and shall not exceed the maximum tension specified by the cable manufacturer. The mechanical stress placed upon the cable during installation shall be such that the cable is not twisted or stretched. A cable feeder guide shall be used between the cable reel and the face of the duct or conduit to protect the cable and guide it into the duct or conduit as it is unspooled from the reel. As the cable is unspooled from the reel, it shall be inspected for jacket defects or damage. The cable shall not be kinked or crushed and the minimum bend radius of the cable shall not be exceeded during installation. Cable shall be hand fed and guided through each manhole and additional lubricant shall be applied at all intermediate manholes. When practicable, the center pulling technique shall be used to lower pulling tension. That is, the cable shall be pulled from the center point of the cable run towards the end termination points.

      The method may require the cable to be pulled in successive pulls. If the cable is pulled out of a junction box or manhole the cable shall be protected from dirt and moisture by laying the cable on a ground covering.

C. Service Loops: Each fiber optic cable shall have service loops of not less than 3 meters 9.8 feet in length at each end. The service loops shall be housed in a service loop enclosure.

D. Splices
   1. No splices will be permitted unless the length of cable being installed exceeds the maximum standard cable length available from a manufacturer or unless fiber optic pigtails are used to connect transmitters, receivers, or other system components for terminations to the fiber. Splices shall be

made using the method recommended by the cable manufacturer. Splices shall be housed in a splice enclosure and shall be encapsulated with an epoxy, ultraviolet light cured splice encapsulant or otherwise protected against infiltration of moisture or contaminants. FO splices shall be field tested at the time of splicing. Fusion splices shall have less than 0.2 dB loss.

2. Mechanical splices shall have less than 0.5 dB loss. There shall be no more than 1 splice per kilometer 0.62 mile in any of the FO cables excluding terminations. Field splices shall be located in cable boxes. Sufficient cable shall be provided in each splicing location to properly rack and splice the cables, and to provide extra cable for additional splices. Cable ends shall be protected with end caps except during actual splicing. During the splicing operations, means shall be provided to protect the unspliced portions of the cable and its fibers from the intrusion of moisture and other foreign matter.

E. Connectors: Fibers at each end of the cable shall have jumpers or pigtails installed of not less than 1 meter 3 feet in length. Fibers at both ends of the cable shall have connectors installed on the jumpers. The mated pair loss, without rotational optimization, shall not exceed 1.5 dB. The pull strength between the connector and the attached fiber shall not be less than 22.7 kilograms, 50 pounds.

F. Identification and Labeling: Identification tags or labels shall be provided for each cable. Markers, tags and labels shall use indelible ink or etching which will not fade in sunlight, or in buried or underground applications. Markers, tags, and labels shall not become brittle or deteriorate for a period of 20 years. Label all termination blocks and panels with cable number or pair identifier for cables in accordance with EIA 606 and as specified. The labeling format shall be identified and a complete record shall be provided to the Government with the final documentation. Each cable shall be identified with type of signal being carried and termination points.

G. Enclosure Sizing and Cable: Termination enclosures shall be sized to accommodate the FO equipment to be installed. Sizing shall include sufficient space for service loops to be provided and to accommodate a neat, workmanlike layout of equipment and the bend radii of fibers and cables terminated inside the enclosure.

H. Enclosure Penetrations: Enclosure penetrations shall be from the bottom and shall be sealed with rubber silicone sealant to preclude the entry of water. Conduits rising from underground shall be internally sealed.

I. Conduit-Enclosure Connections: Conduit-enclosure connections shall be protected by tack welding or brazing the conduit to the enclosure. Tack welding or brazing shall be done in addition to standard conduit-enclosure connection methods as described in NFPA 70. Any damage to the enclosure or its cover's surface protection shall be cleaned and repaired using the same type of surface protection as the original enclosure.

3.2 TESTING

A. General: The Contractor shall provide personnel, equipment, instrumentation, and supplies necessary to perform testing.

B. Contractor's Field Test: The Contractor shall verify the complete operation of the data transmission system in conjunction with field testing associated with systems supported by the fiber optic data transmission system prior to formal acceptance testing. Field tests shall include a flux density test. These tests shall be performed on each link and repeated from the opposite end of each link.

C. Optical Time Domain Reflectometer Tests: Optical time domain reflectometer tests shall be performed using the FO test procedures of EIA 455-59. An optical time domain reflectometer test shall be performed on all fibers of the FO cable on the reel prior to installation. The optical time domain reflectometer shall be calibrated to show anomalies of 0.2 dB as a minimum. An optical time domain reflectometer test shall be performed on all fibers of the FO cable after it is installed. The optical time domain reflectometer shall be calibrated to show anomalies of 0.2 dB as a minimum. If the optical time domain reflectometer test results show anomalies greater than 1 dB, the FO cable segment is unacceptable. The unsatisfactory segments of cable shall be replaced with a new segment of cable. The new segment of cable shall then be tested to demonstrate acceptability.

D. Power Attenuation Test: Power attenuation test shall be performed at the light wavelength of the transmitter to be used on the circuit being tested. The flux shall be measured at the FO receiver end and shall be compared to the flux injected at the transmitter end. There shall be a jumper added at each end of the circuit under test so that end connector loss shall be validated. Rotational optimization of the connectors will not be permitted. If the circuit loss exceeds the calculated circuit loss by more than 2 dB, the circuit is unsatisfactory and shall be examined to determine the problem. The Engineer shall be notified of the problem and what procedures the Contractor proposes to eliminate the problem. The Contractor shall prepare and submit a report documenting the results of the test.

E. Gain Margin Test: The Contractor shall test and verify that each circuit has a gain margin which exceeds the circuit loss by at least 6 dB.

+ + END OF SECTION + +

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SECTION 16900

CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: Furnish all labor, materials, equipment and incidentals required to provide miscellaneous equipment and controls as specified and shown on the Drawings. The control schematics shall be as shown on the Drawings.

B. Related Work Specified Elsewhere:
   1. Section 13430, Control Panels and Enclosures.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. National Electrical Suppliers Association.
   2. Underwriters Laboratories, Inc.
   3. Factory Mutual, Inc.
   4. The National Electrical Code.
   5. The National Electrical Safety Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit supplier's technical information for miscellaneous equipment and controls proposed for use.

PART 2 - PRODUCTS

2.1 CONTROL PANELS

A. General:
   1. Provide the panels completely assembled, wired-up and ready for field connections in accordance with the respective control schematics shown the Drawings.
   2. Panel construction component selection shall comply with Section 13430, Control Panels and Enclosures.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with requirements specified in Section 13430, Control Panels and Enclosures.

B. Install miscellaneous equipment and controls and wiring in conformance to the National Electrical Code.

+ + END OF SECTION + +