SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:

a. Constant-volume air systems.

b. Variable-air-volume systems.

2. HVAC equipment quantitative-performance settings.

3. Verifying that automatic control devices are functioning properly.

4. Reporting results of activities and procedures specified in this Section.

1.2 SUBMITTALS

A. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit 4 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

C. Warranties specified in this Section.

1.3 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC, NEBB or TABB.

B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems." SMACNA's TABB "HVAC Systems - Testing, Adjusting, and Balancing." Or, TABB "Contractors Certification Manual."

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."

E. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.7.2.3 - "System Balancing."

1.4 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.

1.5 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.6 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.

2. Systems are balanced to optimum performance capabilities within design and installation limits.

B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.

2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCT

2.1 MATERIAL COMPATIBILITY

All materials used for permanent installation pertaining to testing and balancing shall be compatible with the room environment. The contractor and supplier shall coordinate with the chemicals and gases that shall be present in the room. Materials selected shall not be subject to negative effect such as premature corrosion, etc.

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.

1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01.

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 equipment performance data including fan curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

L. Examine equipment for installation and for properly operating safety interlocks and controls.

M. Examine automatic temperature system components to verify the following:

1. Dampers and other controlled devices are operated by the intended controller.

2. Dampers are in the position indicated by the controller.

3. Integrity of dampers for free and full operation and for tightness of fully closed and fully open positions.

4. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.

5. Sensors are located to sense only the intended conditions.

6. Sequence of operation for control modes is according to the Contract Documents.

7. Controller set points are set at indicated values.

8. Interlocked systems are operating.

9. Changeover from heating to cooling mode occurs according to indicated values.

N. 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 system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.

2. Automatic temperature-control systems are operational.

3. Equipment and duct access doors are securely closed.

4. 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 ASHRAE 111, AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's TABB "HVAC Systems - Testing, Adjusting, and Balancing" and this Section.

1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."

B. Cut equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

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. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

C. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

D. Verify that motor starters are equipped with properly sized thermal protection.

E. Check dampers for proper position to achieve desired airflow path.

F. Check for airflow blockages.

G. Check condensate drains for proper connections and functioning.

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 fan static pressures to determine actual static pressure as follows:

a. Measure static pressure directly at the fan outlet

b. Measure inlet static pressure of single-inlet fans in the inlet.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes 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 static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

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. 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 terminal 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 terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using 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, model, and serial numbers.

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 for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, 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 WATER HEATERS

A. Measure entering- and leaving-water temperatures and water flow at re-circulation pump where applicable.

3.9 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.10 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.11 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.

2. Air Outlets and Inlets: 0 to minus 10 percent.

3.12 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Fan curves.

2. Manufacturers' test data.

3. Field test reports prepared by system and equipment installers.

4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.

2. Name and address of TAB firm.

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 firm 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, type size, and fittings.

14. Notes to explain why certain final data in the body of reports varies from indicated values.

15. Test conditions for fans and pump performance forms including the following:

a. Settings for outside-, return-, and exhaust-air dampers.

b. Conditions of filters.

c. Cooling coil, wet- and dry-bulb conditions.

d. Fan drive settings.

e. Other system operating conditions that affect performance.

E. 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 outside, supply, return, and exhaust airflows.

2. Water flow rates.

3. Duct, outlet, and inlet sizes.

4. Pipe and valve sizes and locations.

5. Terminal units.

6. Balancing stations.

7. Position of balancing devices.

3.13 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 09 00
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for heating and ventilating units not supplied with factory-wired controls.

B. This contractor shall provide control wiring, components, and programming necessary to comply to the sequence of operations.

1.2 SUBMITTALS

A. Product Data: For each control device indicated.

B. Shop Drawings:

1. Schematic flow diagrams.

2. Power, signal, and control wiring diagrams.

3. Details of control panel faces.

4. SCADA System Interfacing Hardware: Wiring diagrams and schematic control diagrams showing requested SCADA connection points.

5. Control System Software: Schematic diagrams, written descriptions, and points list.

C. Software and firmware operational documentation.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 MATERIAL COMPATIBILITY

A. All materials used for HVAC controls shall be compatible with the room environment. The contractor and supplier shall coordinate with the chemicals and gases that shall be present in the room. Materials selected shall not be subject to negative effect such as premature corrosion, etc.

2.2 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.

2.3 CONTROL SYSTEM

A. Allowed Manufacturers:
1. ABB
2. Alerton
3. Schneider Electric
4. Staefa
5. Automated Logic
6. Johnson Controls
7. Siemens

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, control panel boxes, other apparatus, accessories, and software connected to controllers and programmed to control mechanical systems

2.4 CONTROL EQUIPMENT & COMPONENTS

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

    a. Discrete/digital, analog, and pulse I/O.

    b. Monitoring, controlling, or addressing data points.

    c. Software applications, scheduling, and alarm processing.

    d. Testing and developing control algorithms without disrupting field hardware and controlled environment.

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

    a. Global communications.

    b. Discrete/digital, analog, and pulse I/O.

    c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation.

C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation[with three-position (on-off-auto) override switches and status lights].

5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA)[with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer].

6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.

7. Universal I/Os: Provide software selectable binary or analog outputs.

D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.

3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.

2. Maximum response time of 10 nanoseconds.

3. Minimum transverse-mode noise attenuation of 65 dB.

4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.5 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] <Insert number>-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. Enclosure: Dustproof rated for operation at 32 to 120 deg F (0 to 50 deg C).

2.6 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.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

2.7 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Approved 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.

2. Accuracy: Plus or minus 0.36 deg F (0.2 deg C) at calibration point.

3. Wire: Twisted, shielded-pair cable. (Plenum rated where applicable).

4. Insertion Elements in Ducts: Single point, 18 inches (460 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: 36 inches (915 mm) long, flexible, 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: Exposed.

    b. Set-Point Indication: Exposed.

    c. Thermometer: Red-reading glass.

    d. Color: Manufacturer's standard.

    e. Orientation: [\Vertical.

C. RTDs and Transmitters:

1. Available Manufacturers:

    a. BEC Controls Corporation.

    b. MAMAC Systems, Inc.

    c. RDF Corporation.

2. Accuracy: Plus or minus 0.2 percent at calibration point.

3. Wire: Twisted, shielded-pair cable.

4. Insertion Elements in Ducts: Single point, 18 inches (460 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: 48 inches (1200 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: Exposed.

    b. Set-Point Indication: Exposed.

    c. Thermometer: Red-reading glass.

    d. Color: Manufacturer's standard.

    e. 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. Room Sensor Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Exposed.

2. Set-Point Indication: Exposed.

3. Thermometer: Red-reading glass.

4. Color: Manufacturer's standard.

5. Orientation: Vertical.

E. Room sensor accessories include the following:

1. Insulating Bases: For sensors located on exterior walls.

2. Guards: Locking; heavy-duty, transparent plastic

3. Adjusting Key: As required for calibration and cover screws.

2.8 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 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.

C. 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.

D. 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.

E. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

F. Electronic Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.9 THERMOSTATS

A. Available Manufacturers:

1. Erie Controls.
2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
3. Heat-Timer Corporation.
4. Sauter Controls Corporation.
5. Tekmar Control Systems, Inc.
6. Theben AG - Lumilite Control Technology, Inc.

B. 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."

C. 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.

D. 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.

E. 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.

F. Room Thermostat Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Exposed.

2. Set-Point Indication: Exposed.

3. Thermometer: [Red-reading glass.

4. Color: Manufacturer's standard

5. Orientation: Vertical.

G. Room thermostat accessories include the following:

1. Insulating Bases: For thermostats located on exterior walls.

2. Thermostat Guards: Locking; heavy-duty, transparent plastic.

3. Adjusting Key: As required for calibration and cover screws.

4. Set-Point Adjustment: 1/2-inch- (13-mm-) diameter, adjustment knob.

H. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

I. 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.

J. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- 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.

K. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- [or automatic-]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.

L. Thermostats used in the Headworks building shall be corrosion resistant to methane and hydrogen sulfate gas.

2.10 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. 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.

2. 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).

3. 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. Available Manufacturers:

a. Belimo Aircontrols (USA), Inc.

2. Dampers: Size for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.

b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.

c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.

d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.

e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

3. Coupling: V-bolt and V-shaped, toothed cradle.

4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.

6. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.

7. Temperature Rating: 40 to 104 deg F.

8. Run Time: 30 seconds

2.11 DAMPERS

A. Available Manufacturers:

1. Air Balance Inc.

2. Don Park Inc.; Autodamp Div.

3. TAMCO (T. A. Morrison & Co. Inc.).

4. United Enertech Corp.

5. Vent Products Company, Inc.

6. Ruskin

7. Louvers and Dampers, Inc.

B. Dampers: AMCA-rated, 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 oil-impregnated sintered bronze 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.

2.12 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

B. Install guards on thermostats where indicated.

C. Install automatic dampers according to Division 23 Section Air Duct Accessories.

D. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

E. Install labels and nameplates to identify control components according to Division 23 Section Identification for HVAC Piping and Equipment.

F. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

G. Install electronic cables according to Division 27.

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, cabinets, building wire, and communication cable according to Divisions 26 & 27.

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.

B. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

C. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.3 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. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

6. Test each system for compliance with sequence of operation.

7. Test software and hardware interlocks.

C. Control 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 pressure instruments and self-contained pressure regulators.

6. Check temperature instruments and material and length of sensing elements.

7. Check Control 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.

3.4 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 01 for Demonstration and Training.

PART 4 - SEQUENCE OF OPERATION

4.1 DUCT FREE SPLIT SYSTEM HEAT PUMP AC-1

A. Each unit shall run under its own factory controls. A remote, hard wired, wall mounted controller (thermostat) shall be provided. The ATC contractor shall wire and program all necessary item associated with the system. The setpoint shall be programmed to 68°F (adjustable).

4.2 ELECTRIC UNIT HEATERS UH-1

A. Each unit shall run under its own factory controls. A remote, hard wired, wall mounted controller (thermostat) shall be provided. The ATC contractor shall wire and program all necessary item associated with the system. The setpoint shall be programmed to 72°F (adjustable).

4.3 EXHAUST FANS

A. The exhaust fans shall operate continuously.

B. Fan operation and status shall be monitored by the SCADA system.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant:

1. Suction Lines for Air-Conditioning Applications: 185 psig.

2. Liquid Lines: 325 psig.

1.3 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.

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. 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.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L

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 115-V ac coil.

6. Working Pressure Rating: 400 psig (2760 kPa).

7. Maximum Operating Temperature: 240 deg F (116 deg C).

8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.

2. Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Seat Disc: Polytetrafluoroethylene.

4. End Connections: Threaded.

5. Working Pressure Rating: 400 psig (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. 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).

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.

2. Drain Plug: Brass hex plug.

3. Screen: 100-mesh monel.

4. End Connections: Socket or flare.

5. Working Pressure Rating: 500 psig (3450 kPa).

6. Maximum Operating Temperature: 275 deg F (135 deg C).

J. Moisture/Liquid Indicators:

1. Body: Forged brass.

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.

3. Indicator: Color coded to show moisture content in ppm.

4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.

5. End Connections: Socket or flare.

6. Working Pressure Rating: 500 psig (3450 kPa).

7. Maximum Operating Temperature: 240 deg F (116 deg C).

K. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.

2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.

3. Desiccant Media: Activated alumina or charcoal.

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. Rated Flow: 2 tons

9. Working Pressure Rating: 500 psig (3450 kPa).

10. Maximum Operating Temperature: 240 deg F (116 deg C).

L. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.

2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.

3. Desiccant Media: Activated alumina or charcoal.

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. Rated Flow: 5 tons

9. Working Pressure Rating: 500 psig (3450 kPa).

10. Maximum Operating Temperature: 240 deg F (116 deg C).

M. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.

2. End Connections: Socket or threaded.

3. Working Pressure Rating: 500 psig (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.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. All refrigerant tubing shall be Copper, Type K, drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at strainers if they are not an integral part of strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.

G. 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.

H. 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.

I. 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.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.

2. Thermostatic expansion valves.

3. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

L. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping adjacent to machines to allow service and maintenance.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Refer to Division 23 09 00 Control for HVAC for control wiring, and sequence of operation.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section Access Doors and Frames if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping with sheet-metal protective cover in locations where installed on building exterior.

M. 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.

N. When brazing, 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.

O. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

P. Seal penetrations through fire and smoke barriers according to Division 07.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

S. Seal pipe penetrations through exterior walls according to Division 07 Section Joint Sealants for materials and methods.

T. Identify refrigerant piping and valves according to Division 23 Section Identification for HVAC Piping and Equipment.

3.4 PIPE JOINT CONSTRUCTION

A. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.

2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 INSULATION

A. Provide 1” thick closed cell elastomeric foam insulation in tubular form on all refrigerant piping (Armaflex or equal).

3.6 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23 Section Hangers and Supports for HVAC Piping and Equipment.

B. Install the following pipe attachments:

1. Adjustable metal clevis hangers for individual horizontal runs less than 20 feet long.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.

3. Spring hangers to support vertical runs.

4. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.

2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.

3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.

4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.

5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

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 and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

a. Fill system with nitrogen to the required test pressure.

b. System shall maintain test pressure at the manifold gage throughout duration of test.
c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.8 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

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.

2. Round ducts and fittings.

3. Sheet metal materials.

4. Sealants and gaskets.

5. Hangers and supports.

6. Seismic-restraint devices.

B. Related Sections:

1. Division 23 05 93 “Testing, Adjusting, and Balancing” for HVAC for testing, adjusting, and balancing requirements for metal ducts.

2. Division 23 31 16 “Nonmetal Ducts” for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.

3. Division 23 33 00 “Air Duct Accessories” for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports 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" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems.

1. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. 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.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.

3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 Material Compatibility

A. All materials used for metal ducts shall be compatible with the room environment. The contractor and supplier shall coordinate with the chemicals and gases that shall be present in the room. Materials selected shall not be subject to negative effect such as premature corrosion, etc.

B. All HVAC and exhaust ductwork, fittings, and supports in the Headworks building shall be aluminum or stainless steel.

2.2 RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 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. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support

intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than [60 Inches (1524 mm)] <Insert dimension> in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger Than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: [G60 (Z180)] [G90 (Z275)].

2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 (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.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch (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).

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: [3 inches (76 mm)] [4 inches (102 mm)] [6 inches (152 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, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.

4. Water resistant.

5. Mold and mildew resistant.

6. VOC: Maximum 75 g/L (less water).

7. Maximum Static-Pressure Class: 10-inch wg (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. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.

3. Grade: NS.

4. Class: 25.

5. Use: O.

6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (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.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.7 SEISMIC-RESTRAINT DEVICES

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

1. 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. Seismic Restraint Systems (SRS).

8. TOLCO; a brand of NIBCO INC.

9. 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: Reinforcing steel angle clamped 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 23 Section Air Duct Accessories for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 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 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (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 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (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."

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 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 23 Section Air Duct Accessories.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section Air Duct Accessories for access panels and doors.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.8 START UP

A. Air Balance: Comply with requirements in Division 23 Section Testing, Adjusting, and Balancing for HVAC.

B. Supply and Return Ducts:

1. Ducts Connected to Make-up air units and Packaged rooftop units:

a. Pressure Class: Positive or negative 2-inch wg (500 Pa)

b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 12.

d. 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 1-inch wg (250 Pa)

b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.

c. SMACNA Leakage Class for Rectangular: 24

d. SMACNA Leakage Class for Round and Flat Oval: 12

D. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

2. PVC-Coated Ducts:

    a. Exposed to Airstream: Match duct material.

    b. Not Exposed to Airstream: Galvanized..

3. Stainless-Steel Ducts:

    a. Exposed to Airstream: Match duct material.

    b. Not Exposed to Airstream: Match duct material.

4. Aluminum Ducts: Aluminum.

E. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

    a. Velocity 1000 fpm (5 m/s) or Lower:

        1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

        2) Mitered Type RE 4 without vanes.

    b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):

        1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

        2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.

        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

    c. Velocity 1500 fpm (7.6 m/s) or Higher:

        1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

        2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.

2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, [12 Inches (305 mm)] <Insert dimension> and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, [14 Inches (356 mm)] <Insert dimension> and Larger in Diameter: [Standing seam] [Welded].

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."

a. Rectangular Main to Rectangular Branch: 45-degree entry.

b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.

b. Velocity 1000 to 1500 fpm: Conical tap.

c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Control dampers.
2. Flange connectors.
3. Flexible connectors.
4. Duct accessory hardware.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.1 Material Compatibility

A. All materials used for duct accessories shall be compatible with the room environment. The contractor and supplier shall coordinate with the chemicals and gases that shall be present in the room. Materials selected shall not be subject to negative effect such as premature corrosion, etc.

2.2 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 (Z180)

2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and a No. 2 finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch (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 CONTROL DAMPERS

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

1. American Warming and Ventilating; a division of Mestek, Inc.

2. Arrow United Industries; a division of Mestek, Inc.

3. Cesco Products; a division of Mestek, Inc.

4. Duro Dyne Inc.

5. Flexmaster U.S.A., Inc.

6. Greenheck Fan Corporation.

7. Lloyd Industries, Inc.

8. M&I Air Systems Engineering; Division of M&I Heat Transfer Products Ltd.

9. McGill AirFlow LLC.

10. METALAIRE, Inc.

11. Metal Form Manufacturing, Inc.

12. Nailor Industries Inc.

13. NCA Manufacturing, Inc.

14. Ruskin Company.

15. Vent Products Company, Inc.

16. Young Regulator Company.

17. United Enertech

B. Frames:

1. Hat shaped.

2. Galvanized-steel channels, 0.064 inch (1.62 mm) thick.

3. Mitered and welded corners.

C. Blades:

1. Multiple blade with maximum blade width of 8 inches (200 mm).

2. Parallel- and opposed-blade design.

3. Stainless steel or aluminum.

4. 0.064 inch (1.62 mm) thick.

5. Blade Edging: Closed-cell neoprene edging.

6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

D. Blade Axles: 1/2-inch- (13-mm-) diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).

E. Bearings:

1. Oil-impregnated bronze.

2. 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.

3. Thrust bearings at each end of every blade.

2.4 FLANGE CONNECTORS

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

1. Ductmate Industries, Inc.

2. Nexus PDQ; Division of Shilco Holdings Inc.

3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.5 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.

2. Duro Dyne Inc.

3. Ventfabrics, Inc.

4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to 2 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. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).

2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.

3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 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.

2.6 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.

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 control 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 flexible connectors to connect ducts to equipment.

H. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

I. Install duct test holes where required for testing and balancing purposes.

J. 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 and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.

END OF SECTION

SECTION 23 34 23
HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Centrifugal Utility Set Ventilators.

2. Cabinet Ventilators.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

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.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

C. UL Standard: Power ventilators shall comply with UL 705.

PART 2 - PRODUCTS

2.1 MATERIAL COMPATIBILITY

A. All materials used for all fans shall be compatible with the room environment. The contractor and supplier shall coordinate with the chemicals and gases that shall be present in the room. Materials selected shall not be subject to negative effect such as premature corrosion, etc.

2.2 WALL MOUNTED PROPELLER FAN

A. Furnish and install complete the propeller ventilation fan shown and specified on the drawings.

B. Fan shall be direct-connection, motor-driven type. Wheels shall have steel or aluminum blades with heavy nubs. Mounting rings or plates shall be cast or die-formed to smooth curves where the air enters the wheel. Mounting plates shall prevent distortion and shall be turned up at all edges or braced with steel angles. A wire mesh guard and wall mounting box and hardware shall be provided with fan. Unit shall bear AMCA Certified Performance Seal.

C. Fan shall be Greenheck, Twin City, Penn or Cook.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using elastomeric mounts having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Division 23 Section Vibration and Seismic Controls for HVAC Piping and Equipment.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Division 23 Section Identification for HVAC Piping and Equipment.

E. Equipment grounding and wiring according to Division 26.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

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.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION

PAGE INTENTIONALLY LEFT BLANK

SECTION 23 37 13
GRILLES & LOUVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Registers and grilles.

2. Louvers.

B. Related Sections:

1. Division 23 33 00 Air Duct Accessories for fire and smoke dampers and volume-control dampers not integral to grilles.

1.2 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. Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 MATERIAL COMPATIBILITY

A. All materials used for all fans shall be compatible with the room environment. The contractor and supplier shall coordinate with the chemicals and gases that shall be present in the room. Materials selected shall not be subject to negative effect such as premature corrosion, etc.

2.2 REGISTERS AND GRILLES

A. Adjustable Bar Register:

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. Anemostat

b. Hart & Cooley

c. Krueger

d. Nailor

e. Price

f. Titus

g. Tuttle & Bailey

2. Material: Aluminum

3. Finish: Baked enamel, white

4. Face Blade Arrangement: Horizontal spaced 3/4 inch (19 mm) apart.

5. Core Construction: Removable.

6. Rear-Blade Arrangement: Vertical spaced 3/4 inch (19 mm) apart.

7. Frame: 1-1/4 inches (32 mm) wide.

8. Mounting Frame: Surface

9. Mounting: Countersunk screw.

10. Damper Type: Adjustable opposed blade with face mounted operator.

B. Rectangular and Square Ceiling Diffusers

2.3 Louvers:

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. Aerolite
2. Louvers & Dampers
3. Pottorff
4. Safe-Air Dowco
5. Greenheck
6. United Enertech

B. At all air system openings in outside wall, install storm louvers.

C. Construct louvers of extruded anodized aluminum (color by architect).

D. Louvers to be drainable type.

E. Slats shall be inclined at least 45 degrees from the horizontal and overlap a minimum of 1". Slats over 40" long shall have a 2" wide intermediate support. The exterior face of the louver shall be neatly fitted to the building wall, flashed at top, and caulked at sides and bottom. New open area for air passage shall be at least 50% of the nominal size. On the inside face of the louver, install a removable screen, consisting of 1/2" mesh galvanized wire screen in a galvanized channel frame. The louver shall have a sub frame and shall be removable.

F. Caulk around louver frames with clear G.E. silicone sealer after installation.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION OF GRILLES

A. Install grilles level and plumb.

B. Install grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 INSTALLATION OF LOUVERS

A. Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Provide perimeter reveals and openings of uniform width for Repair damaged finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory and refinish entire unit or provide new units.

D. Protect galvanized and nonferrous-metal surfaces that will be in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint.

3.3 ADJUSTING

A. After installation, adjust registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

PAGE INTENTIONALLY LEFT BLANK

SECTION 23 55 33
ELECTRIC UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes electric unit heaters.

1.2 SUBMITTALS

A. Product Data: For each type of electric unit heater indicated. Include rated capacities, operating characteristics, and accessories.

B. Field quality-control test reports.

C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4 2021 IECC Compliance: Applicable requirements in 2021 IECC Table C403.3.2 – Minimum Efficiency Requirements.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchanger of unit heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIAL COMPATIBLITY

A. All materials used for unit heaters shall be compatible with the room environment. The contractor and supplier shall coordinate with the chemicals and gases that shall be present in

the room. Materials selected shall not be subject to negative effect such as premature corrosion, etc.

2.2 ELECTRIC UNIT HEATERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by:

1. Chromalox or prior approved equal.

B. Description: Factory assembled and wired, and complying with ANSI standard for electric unit heaters in hazardous locations.

C. Housing & Louver: Powder coated steel, with integral draft hood and inserts for suspension mounting rods.

D. Heat Exchanger: Stainless steel.

E. Burner Material: Stainless steel.

F. Unit Fan: Propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.

G. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
2. Control transformer.
3. Thermostats: Devices and wiring are specified in Division 23 Section "Instrumentation and Control for HVAC.". Single-stage, wall-mounting type with 50 to 90 deg F operating range and fan on switch.

H. Discharge Louvers: Independently adjustable horizontal blades.

I. Accessories:

1. Vertical discharge louvers.
2. Discharge Nozzle: Discharge at 25 to 65 degrees from horizontal.
3. Four-point suspension kit.
4. Summer fan switch.

J. Capacities and Characteristics per schedules on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect unit heaters and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.

B. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb. Provide anchorage or bracing to resist lateral translation or sliding, uplift or overturning, and rotation or swaying. Use means of restraint that provide for positive attachment (e.g., a through-bolted connection) and that do not rely on friction effects alone.

C. Install any process piping or equipment adjacent to unit heater to allow service and maintenance.

D. Electrical Connections: Comply with applicable requirements in Division 26 Sections.

1. Install electrical devices furnished with heaters but not specified to be factory mounted.

E. Adjust initial temperature set points.

F. Adjust burner and other unit components for optimum heating performance and efficiency.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 23 81 26
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes split-system heat pump units consisting of separate fan-coil unit and compressor components. Units are designed for exposed wall mounting.

1.2 SUBMITTALS

A. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace split-system air-conditioning units that fail in materials and workmanship within [five] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier

2. L.G.

3. Lennox

4. Mitsubishi

2.2 INDOOR FAN-COIL UNIT

A. Concealed Unit Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.

1. Insulation: Faced, glass-fiber duct liner.

2. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1-2004.

3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Evaporator Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.

D. Fan Motor: Multispeed.

E. Filters: 1 inch (25 mm) thick, in fiberboard frames.

2.3 OUTDOOR COMPRESSOR 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. Compressor: Hermetically sealed [reciprocating] [scroll] type with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.

E. Fan: Aluminum-propeller type, directly connected to motor.

F. Motor: Permanently lubricated, with integral thermal-overload protection.

G. Low Ambient Kit: Permits operation down to 0 deg F.

H. Mounting Base: Per detail for roof mounted equipment, or 18” high factory roof mounting kit from Diversitech or Quick-sling.

I. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.4 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

1. Minimum Insulation Thickness: 1 inch thick closed cell elastomeric type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure. Provide a clean installation with refrigerant, condensate, power, and control running in lines parallel to the building.

B. Install pad-mounted outdoor compressor on equipment base. Provide 1/2" thick neoprene vibration isolators and anchor to pad.

3.2 CONNECTIONS

A. Connect refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

B. Connect supply and return water coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

C. Connect supply and return condenser connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

D. Charge with refrigerant to pressures as per manufacturer recommendations.

E. Install piping adjacent to unit to allow service and maintenance.

3.3 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION

SECTION 260500 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. General requirements which apply to all electrical aspects of the work.

B. Related Sections

1. The Contract Documents are a single integrated document. As such, all Divisions and Sections are applicable. The Contractor and its Subcontractors are responsible to review all parts of the Contract Documents in order to provide a complete and coordinated project.

1.2 REFERENCES

A. The installation and commissioning of the Electrical System shall conform to all applicable codes, regulations, standards and specifications, including, but not limited to those listed below. These publications are referenced to by designation but not by edition. The latest edition accepted by the Authority Having Jurisdiction in effect at the time of bid shall govern.

1. State and Local Codes and Authority Having Jurisdiction (AHJ)
2. National Electric Code (NEC).
3. National Fire Protection Association (NFPA)
4. Institute of Electrical and Electronic Engineers (IEEE)
5. American National Standards Institute (ANSI)
6. American Society for Testing and Materials (ASTM)
7. Insulated Cable Engineers Association (ICEA)
8. National Electrical Manufacturers Association (NEMA)
9. Federal Occupational Safety and Health Act (OSHA)
10. Underwriters Laboratories, Inc. (UL)
11. International Society of Automation (ISA)

1.3 DEFINITIONS

A. Refer to the Contract Drawings sheet E001 for a list of abbreviations associated with the Electrical System. In addition, the following definitions are used in this section:

1. AHJ – Authority Having Jurisdiction
2. I&C – Instrumentation and Controls
3. IS – Instrumentation Supplier

4. NEC – National Electric Code
5. VFD – Variable Frequency Drive
6. UL - Underwriters Laboratories, Inc.

1.4 ELECTRICAL SYSTEMS REQUIREMENTS

A. Work provided outside of Contractor's scope:
   1. The following equipment is being furnished by the Owner (See Veolia Submittal):
      a. Membrane blowers
      b. Membrane permeate pumps
      c. Membrane control panel
      d. Air compressor for Membrane instruments
      e. Membrane instrumentation
      f. Biosolids holding tank blowers

B. The Work is to provide all labor and materials necessary for erecting a complete and operational Electrical System, tested and ready for continuous use as described by the Contract Documents. The Electrical System shall be constructed in accordance with the Contract Documents, and Federal, State, and Local codes and regulations. In addition, the Work shall adhere to the following general provisions:

   1. The Electrical Contractor shall obtain all necessary permits required by the AHJ. In addition, the Electrical Contractor shall ensure that all inspections required by the AHJ are coordinated, conducted and documented.

   2. All work shall be completed in a neat, workmanlike manner in accordance with the latest NEC standards of installation under competent supervision.

   3. The Electrical Contractor shall visit the job site prior to bidding to become familiar with existing conditions and other factors, which may affect the execution of the work. Include all related costs in the initial bid proposal.

   4. Coordinate work with the utilities providing services on this project. This may include but is not limited to the electric utility, telephone utility, cable TV/Internet utility. All electrical work associated with utilities shall be provided and installed per the utility requirements.

   5. All materials shall be new and of the best quality, manufactured in accordance with the requirements listed in part 1.2 of this section. The Contractor shall furnish and install the parts and pieces necessary to the installation of equipment, in accordance with the best practice of the trade, and in conformance with the requirements of these Contract Documents.

   6. Protect all electrical material and equipment that is being stored or has been installed against damage by other trades, weather conditions, or any other preventable causes. Equipment damaged during shipping, storage or construction, prior to acceptance by the engineer or the owner, will be rejected as defective.

7. Leave the site clean. Remove all debris, empty cartons, tools, conduit, wire scraps and all miscellaneous spare equipment and materials used in the work during construction. All components shall be free of dust, grit and foreign materials, left as new before final acceptance of work. Damaged paint and finishes shall be touched up or repainted with matching color paint and finish.

8. Electrical equipment shall be capable of operating successfully at full-rated load, without failure, at an ambient air temperature and altitude as described in part 2.4 of this section. Electrical equipment not rated for operation at that temperature shall be provided with heating and/or air conditioning to meet the manufacturers' operating temperature.

9. If any contradictions, contrasts, non-homogeneity, or inconsistency appears, the strictest criteria noted and the collective requirements in any and all of the Contract Documents shall apply.

10. The Electrical Contractor shall perform necessary saw cutting, core drilling, excavating, removal, shoring, backfilling, and other work required for the proper installation of conduits, whether inside, or outside of the buildings and structures. The Electrical Contractor shall repair and patch where demolition has taken place in a manner to match existing original structure.

C. In order to provide a complete system, oversee and coordinate with all electrical equipment and services being provided outside of Contractor's scope.

1. The Engineer is responsible to ensure that equipment being supplied by others related to the electrical system complies with the requirements of the Contract Documents

D. Oversee and coordinate with all equipment and services being provided by the Contractor but outside of the Electrical Contractor's scope.

1. Inform all vendors and suppliers providing equipment related to the Electrical System the requirements of Division 26.

2. The Owner is not responsible for any additional costs incurred by requiring vendors and/or subcontractors to meet the requirements of Division 26.

3. If a vendor or supplier is unable to meet the requirements of Division 26, the Contractor may submit in writing to the Engineer the reasons for non-compliance. The Engineer will then evaluate the reasons and determine whether a solution may be determined or if a different vendor or supplier is required.

E. Prepare Electrical System Submittals as required by Division 26 and Section 013300. Coordinate with the IS and the requirements of Division 40 to ensure that all equipment being supplied by the Electrical Contractor and/or IS has been submitted.

F. Oversee the installation of the Electrical System.

G. Actively participate in loop testing as outlined in Division 40.

H. Actively participate in commissioning as outlined in Division 40.

I. Maintain record drawings.
   1. Maintain on the construction site a set of the Electrical Drawings that shall be continuously marked up during construction.
      a. The drawings should be updated at least weekly and will be checked monthly by the Owner's representative.
      b. Upon completion of startup, submit the marked-up drawings to the Engineer for review and for drafting.

J. Prepare O&M manuals.
   1. Provide O&M manuals in accordance with Section 017823.

K. Provide training on electrical equipment that has been installed.

1.5 ACTION SUBMITTALS

A. General
   1. Submittals for Division 26 shall meet the requirements of Section 013300 Contractor Submittals. In addition, the following requirements shall be met:
      a. Submittals shall include bills of materials with quantities, makes, models, exact part numbers and descriptions.
      b. Edit all submittals such that only pertinent information is submitted. Neatly cross out information that does not apply, options that are not being supplied, etc.
      c. Show product dimensions, construction and installation details, wiring diagrams, and specifications.
      d. If there are exceptions to the Contract Drawings and Specifications, provide a list of exceptions with detailed explanations for the exceptions. The Engineer will review the list of exceptions and determine whether a solution may be determined or if the exception(s) will not be allowed.
   2. Furnish submittals required by each Section within Division 26.
   3. When submitting on equipment, use the equipment and instrumentation tags depicted in the Contract Drawings.

B. Recommended Spare Parts Submittal
   1. Submit a list of spare parts for all of the equipment associated with the Electrical System. The list of spare parts shall include list pricing for each item.
   2. Provide the name, address and phone number for each manufacturer and manufacturer's local sales representative.
   3. Indicate whether or not the spare parts are being provided under this contract or not.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. All equipment supplied for this project shall meet the requirements of the NEC and shall be listed by and bearing the label of the UL.

B. The Electrical Contractor shall be a company that has been actively involved in the installation and commissioning of Electrical Systems for a minimum period of five years.

C. The Electrical Contractor shall have adequate facilities, manpower and technical expertise to perform the Work associated with the Electrical System and as outlined by the Contract Documents.

D. The Electrical Contractor shall have similar project experience of at least four successfully completed projects for a similar wastewater system. The Electrical Contractor company must have performed similar work for these projects as required herein.

PART 2 - PRODUCTS

2.1 MATERIALS AND METHODS

A. Materials, equipment, and parts comprising any unit, or part thereof, specified or indicated on the Plans, shall be new and unused, of current manufacture, and of highest grade consistent with the state of the art. Damaged or dirty materials, equipment, and parts are not considered to be new and unused and will not be accepted.

B. Field verification of scale dimensions on Plans is directed, since actual locations, distances, and levels will be governed by actual field conditions. The Contractor shall also review architectural, structural, yard, mechanical, and other Plans, and the accepted electrical and mechanical shop drawings, and shall adjust their work to conform to the conditions indicated therein.

C. The fabricator of major components, such as distribution panelboards, switchgear, and motor control centers, shall also be the manufacturer of the major devices therein. Where possible, the major components shall be manufactured and supplied by the same fabricator.

2.2 AREA DESIGNATIONS

A. Materials, equipment, and parts comprising any unit, or part thereof shall be rated for the area in which it is installed. Follow NEC, NFPA, local, county, and state guidelines.

2.3 MANUFACTURERS

A. All equipment provided for the Electrical System shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

B. Refer to various Division sections for individual equipment manufacturers. Indicated manufacturers are subject to strict compliance with the specifications and complete project documents. The reference to a particular manufacturer does not relieve the Electrical Contractor from conforming to the specified requirements.

C. When providing like electrical components they shall be furnished by a single manufacturer and shall be consistent throughout the project. For example, a 20A 2-way light switch in one building should match a 20A 2-way light switch in another building in both make, model and features.

2.4 EQUIPMENT ASSEMBLIES

A. Equipment assemblies, such as Service Entrance Sections, Switchgear, Switchboards, Control and Distribution Panels, and other custom fabricated electrical enclosures shall bear a UL label as a complete assembly. The UL label on the individual components making up the assembly will not be considered sufficient to meet the present requirement. Whenever a generic UL label does not apply for the assembly, a serialized UL label shall be affixed to the assembly, and the serial number shall be submitted with the assembly record shop drawings.

B. Custom fabricated electrical control panels, and enclosures shall bear a serialized UL label affixed by a local inspector, and the serial number shall be submitted with the assembly record shop drawings.

2.5 OPERATING CONDITIONS

A. The Electrical System shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:
   1. Environment: Type the type of facility this is for such as “Wastewater Treatment Plant”.
   2. Temperature Extremes: -4°F to 104°F (Outdoors); 40°F to 104°F (Indoors).
   3. Relative Humidity: 20% to 90%, non-condensing.

B. Indoor and outdoor electrical equipment shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain electrical devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The Contractor shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. Electrical equipment in hazardous areas shall be suitable for and rated for use in the particular hazardous or classified location in which it is to be installed.

2.6 SEISMIC RESTRAINT

A. The construction area is classified by the International Building Code (IBC) as Seismic Class C. The Code requires that not only the structures, but also major electrical components be designed and installed in a manner which will preclude damage during a seismic event. All electrical equipment shall be securely anchored and seismic braced in accordance with regulations contained in the most recent adopted edition of the IBC, and the Sheet Metal and

Air Conditioning Contractor's National Association (SMACNA) "Guidelines for Seismic Restraints of Electrical Systems".

B. Units mounted and secured directly to structure shall be provided with connectors of sufficient strength to meet the restraining criteria.

C. All electrical equipment which is securely anchored (hard mounted) to the building or structure shall have supports designed to withstand lateral and vertical "G" loadings equal to or greater than IBC requirements and SMACNA guidelines.

D. Shop drawings are required for all equipment anchors, supports and seismic restraints. Submittals shall include weights, dimensions, load/deflection data, center of gravity, standard connections, manufacturer's recommendations, and behavior problems (vibration, thermal, expansion, etc.) associated with equipment.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

B. Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the Engineer. If such tests reveal defects, the equipment shall be replaced.

3.2 MANUFACTURER'S SERVICES

A. Manufacturer's services shall be furnished for the following equipment:

1. Vendor supplied equipment that contain programmable controllers, operator interfaces and/or instrumentation that requires site calibration.
2. Equipment that is equipped with VFD's
3. Conveyors
4. UV equipment

3.3 INSTALLATION

A. The Electrical System indicated throughout the design is diagrammatic and therefore locations of equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Installation of systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination. Where job conditions require reasonable changes in approximated locations and arrangements, or when the Owner exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the Contractor shall make such changes without additional cost to the Owner.

B. Discrepancies indicated on different Plans, between Plans and actual field conditions, or between Plans and Contract Documents shall be promptly brought to the attention of the Engineer for clarification, prior to purchasing and installing equipment.

C. The alignment of equipment and conduit shall be adjusted to accommodate architectural changes, or to avoid work of other trades, without extra expense to the Owner.

D. Items not specifically mentioned in these Contract Documents, or noted on the Plans, or indicated on reviewed shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.

E. The Electrical Contractor shall layout and install electrical work prior to placing floors and walls. Furnish and install sleeves and openings through floors and walls, required for installation of conduits. Sleeves shall be rigidly supported and suitably packed, or sealed, to prevent ingress of wet concrete. Spacers shall be installed in order to prevent conduit movement. Dimensions indicated for electrical equipment and their installation are restrictive dimensions.

F. The Electrical Contractor shall furnish and install inserts and hangers required to support conduits and other electrical equipment. If the inserts, hangers, sleeves, or other mounting hardware are improperly placed, or installed, the Contractor shall do necessary work, at their own expense, to rectify the errors.

G. The Electrical System is integrally connected to I&C, mechanical and structural systems. Coordinate with these other disciplines the installation of these related components.

H. Electrical equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

I. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation system. The Contractor shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the Engineer for approval prior to commencing that Work. Such changes shall not be a basis of claims for extra Work or delay.

J. Instrumentation, control panels, wiring and all other I&C equipment shall be properly tagged and/or labeled per the requirements of Section 260553.

K. Installation of the I&C System shall be according to the finalized Loop Drawings

3.4 FACTORY ACCEPTANCE TESTING (FAT)

A. The IS shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the Engineer and Owner to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, and other pertinent systems and devices. A minimum of 10 days notification shall be furnished to the Engineer prior to testing. No shipments shall be made without the Engineer's approval.

B. For each FAT, the IS shall develop and submit a FAT Plan and Procedure Document within 10 days of the FAT. The FAT Plan and Procedure shall as a minimum shall have the following:
   1. Descriptions of test methods to be performed during the FAT.
   2. FAT Schedule and Procedure
   3. FAT Checklists that allow for sign-off and comments for each test method and procedure.

C. Control Panel Completion Test Methods: The following test methods should be performed during the FAT for each control panel:
   1. Completed Shop Drawings: Demonstrate that the control panel has been built according to the shop drawings and that the shop drawings are accurate.
   2. Panel Layout: Demonstrate that the control panel has been laid out as designed and as required by Division 40.
   3. Power Distribution: Demonstrate all power distribution circuits, including but not limited to AC power circuits, UPS operation, signals and circuits and DC circuits.
   4. Control Circuits: Demonstrate the correct installation of each control circuit. Using a signal generator or multi-meter, show the correct operation of each input, output, relay, barrier, buttons, switches, or any other control device. Demonstrate the proper functionality of any hard-wired interlocks that may be associated with each control circuit.
   5. Panel Networking/Communications: If any form of communications is associated with the control panel, verify the proper operation of each communication port and link.

D. Control Loop Test Methods: In order to demonstrate that the control panel will provide its function as intended, provide the following control loop test methods. If programming for the control panel is provided by others, coordinate with the programmer to have all programming completed and tested prior to the FAT. If needed, coordinate to have the programmer present for the FAT.

1. Alarm Functions: Verify and/or simulate each alarm condition associated with each control loop.
2. Local Manual and Auto Functions: Verify and/or simulate each Local Manual and/or Auto function associated with each control loop.
3. SCADA Manual and Auto Functions: Verify and/or simulate each SCADA Manual and/or Auto function associated with each control loop.
4. Control Loop Interlocks: Demonstrate the functionality of any software interlocks that may be associated with each control loop.

E. If the FAT does not pass and needs to be repeated, the IS shall be responsible for additional per diem costs incurred by the Engineer and Owner.

F. All changes and/or corrections made during the FAT shall be noted on the checklists.

G. Following completion and approval of all FAT, provide the finalized checklists to the Engineer and as part of the equipment shop drawings.

3.5 FIELD QUALITY CONTROL

A. Allow for inspections by the Engineer and/or Owner of the I&C System at any time during the construction. Inspections shall be conducted to verify that the installation is per the requirements of the Contract Documents.

3.6 CALIBRATION

A. Devices provided under Division 40 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment. Such adjustments, if required, shall be made only after consultation with the Engineer.

D. Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. For each instrument calibration, provide a calibration sheet and update the corresponding TR20 Instrument Form with the new calibration data. The Calibration sheet shall include the following as a minimum:

1. Date of calibration
2. Project Name.
3. Tag Number.
4. Manufacturer, model and serial number.
5. Calibration data including range, input, output and measurement at each calibration point.
6. Space for comments.
7. Space for sign-off by party performing calibration.

G. A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the Engineer. The IS shall sign the tag when calibration is complete. The Engineer will sign the tag when the calibration and testing has been accepted.

3.7 LOOP TESTING

A. Each control loop shall have been installed according to the finalized loop drawing. Prior to the commencement of loop testing, the following pre-requisites should have been met:
   1. All associated equipment, conduit and wire has been permanently installed, terminated and inspected.
   2. All wiring has been properly pulled, terminated and labeled.
   3. Each wire has been tested with a point-to-point test.
   4. All control panels and electrical equipment have been checked out and tested as required by Division 26.
   5. All instrumentation has been appropriately installed and calibrated.
   6. Loop Test Forms for each loop to be tested have been created and will be available during the loop testing.

B. Each loop test shall have a Loop Test Form prepared and ready prior to each loop test. The loop test form shall have the following:
   1. Loop Number and Description
   2. Check-Off List with room for sign-off and dated by the IS, Programmer, and Owner's Witness as well as room for comments. The list of items to be checked off for each loop should include but is not limited to the following:
      a. Each power distribution circuit.
      b. Each control circuit.
      c. Each alarm circuit.
      d. Each PLC input/output point.
      e. Each Local Manual, Local Auto, SCADA Manual & SCADA Auto function.
      f. Each hard-wired and software interlock.

C. Upon completion of the above pre-requisites for loop testing, the IS shall oversee and coordinate each loop test. The IS is responsible to be present for all loop testing, whether the equipment was supplied by the IS or not. The IS is responsible to have all responsible parties associated with each loop present. This includes but is not limited to manufacturer representatives, vendor technicians, electrical installers, mechanical installers, and programmer. The IS shall coordinate with the Owner and Engineer to allow for witnessing of loop testing as deemed necessary by the Owner and Engineer.

D. Issues that arise during loop testing should be addressed and fixed immediately. If it is not feasible to immediately fix the issues, the loop testing should be re-scheduled as soon as possible to avoid delays. Any costs associated with re-testing and requiring all parties to return to the site shall in no way be incurred to the Owner.

E. Following a successful loop test, the appropriate parties should sign and date the Loop Test Forms. All Forms shall be certified and submitted to the Engineer as part of the O&M Manuals.

F. Following loop testing, in no way should any parts of the loop be modified. In no way shall any wiring be re-routed or re-terminated. If any such work occurs, all affected loops shall be re-tested at no expense to the Owner.

3.8 COMMISSIONING

A. The IS shall oversee, coordinate and be present during all commissioning activities. The IS shall be responsible for obtaining the assistance of the Contractor and Subcontractors as may be required for commissioning activities.

B. Commissioning shall commence after acceptance of wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Pre-commissioning shall demonstrate proper operation of every system with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

C. Commissioning and test activities shall follow detailed test procedures and check lists accepted by the Engineer. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the Engineer, which include calculated tolerance limits for each step. Completion of system commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the Engineer with a clear and unequivocal statement that system commissioning and test requirements have been satisfied.

D. Where feasible, system commissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of field mounted automatic analog controllers or software-based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of field mounted, and software-based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

E. Electronic control stations incorporating proportional, integral or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

3.9 TRAINING

A. Provide training in accordance with Section 260000.

B. Develop a Training Plan for the training requirements of Division 40 and submit it to the Engineer for approval. Coordinate with the Engineer and Owner the time and locations of each training session. Schedule the trainings for after the equipment has been pre-commissioned.

C. As part of the Training Plan, submit a résumé for each individual to be providing training. Training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

D. Each training session shall include a written agenda.

E. The Contractor shall train the Owner's personnel on the maintenance, calibration and repair of instruments provided.

F. Within 10 days after the completion of each session, the Contractor shall submit the following:
   1. A list of Owner personnel who attended the training.
   2. A copy of the training materials used during the session with notes, diagrams and comments.

END OF SECTION 260000

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.4 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. All conductors, conductor insulation and multiconductor cables shall comply with NEMA WC 70.

B. Wire sizes shall be American Wire Gauge (AWG) sizes with Class B stranded construction Number 2 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape. Conductors #6 AWG or smaller shall be THWN-2 or XHHW-2. Number 4 and larger shall be XHHW-2.

C. Individual or multiple conductor cables for power, control, and alarm circuits of 480 volts or less shall be insulated for not less than 600V.

D. Where wire size is not indicated, they shall be of the size required by the NEC, except that no wire external to panels and motor control centers shall be less than #12 AWG, unless specifically noted on the Plans. Control wires shall be allowed to be #14 so long as there is appropriate protection (fuse or circuit breaker sized at 15A or less).

E. Multi-conductor tray cables shall be rated 600 volts, listed by UL as Type TC cable or ITC for instrumentation cable only per Article 340 of the NEC. The individual conductors shall be UL listed as Type XHHW, with a sunlight-resistant overall jacket. Conductor sizes shall be the same as for power and lighting wire and control wire above. Connectors/Terminators shall be water tight and manufactured of the same material as the cabling system referenced elsewhere in division 26.

F. Multi-conductor tray cables to be installed in classified areas shall be armored, rated 600 volts, listed by UL as Type MC-HL cable per Article 340 of the NEC. The individual conductors shall be UL listed as Type XHHW, with a sunlight-resistant overall jacket. Conductor sizes shall be the same as for power and lighting wire and control wire above. Connectors/terminators shall be rated for classified areas and submitted upon accordingly.

G. All wiring shall be as indicated on the Plans. Wires shall be new and shall be soft drawn copper with not less than 97 percent conductivity. The wire and cable shall have size, grade of insulation, voltage, and manufacturer's name permanently marked on the outer covering at not more than 2-foot intervals. All wires shall conform to the latest Standards of the ASTM, and ICEA, and shall be tested for their full length by these Standards. Insulation thickness shall be not less than that specified by the National Electrical Code.

H. VFD Cable:

1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
2. Type TC-ER with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.
3. Comply with UL requirements for cables in direct burial or Classes I and II, Division 2 hazardous location applications.

I. Table I below describes the conductor color code that shall be followed:

Table I

	120/208VAC	**480VAC**	**12VDC**	**24VDC**	**24VAC**
Phase 1	Black	Brown			
Phase 2	Red	Orange			
Phase 3	Blue	Yellow			
Neutrals/Commons	White	White	Orange/White	Blue/White	Yellow/White
Ground	Green	Green	Green	Green	Green
Control	Red		Orange	Blue	Yellow

J. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Insulated Wire Corporation
2. Cablec Corporation
3. Okonite Company
4. Southwire Company
5. Or Approved Equal

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

B. Connectors and splices shall be rated at not less than 600 volts. Splicing shall join conductors mechanically and electrically to provide a complete circuit prior to installation of insulation.

C. Splices in wires No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, Type I, Class 1, Grade B, Style G, or Type II, Class 1 of FS W-S-610 and conforming to the applicable requirements of UL 486A.

D. Splices in wires No. 8 AWG and larger shall be made with non-insulated, solderless, pressure type connector, Type II, Class 2 of FS W-S-610, conforming to the applicable requirements of UL 486A and UL 486B. They shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket.

E. Insulated conductor splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

F. Bare conductor splices in wet locations or below grade shall be of the exothermic type.

G. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Power Systems, Inc.
2. O-Z/Gedney; EGS Electrical Group LLC.
3. 3M; Electrical Products Division.
4. Or Approved Equal

2.3 PULLING LUBRICANT

A. All cables shall be properly coated with a water-based (wax-based is not acceptable) pulling compound before being pulled into conduits so as to prevent mechanical damage to the cables during installation. Lubricants shall be approved by the cable manufacturer for use with the cable being installed.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Polywater
2. Ideal Aqua-Gel
3. Or Approved Equal

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Stranded for all sizes.

B. Branch Circuits: Copper. Stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway

B. Exposed Feeders and Branch Circuits: Type THWN-2 or XHHW-2 based on wire size requirements described in Part 2, single conductors in raceway. Multiconductor Tray Cable type TC shall be used where runs are to be in cable trays as shown on the drawings.

C. Feeders and Branch Circuits Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THWN-2 or XHHW-2 based on wire size requirements described in Part 2, single conductors in raceway. Metal-clad cable, Type MC shall be allowed in ceilings that are considered dry and non-corrosive areas.

D. Feeders and Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THWN-2 or XHHW-2 based on wire size requirements described in Part 2, single conductors in raceway.

E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

F. Class 1 Control Circuits: Type THWN-2, in raceway. Multiconductor Tray Cable type TC shall be used where runs are to be in cable trays as shown on the drawings.

G. Class 2 Control Circuits: Type THWN-2, in raceway. Power-limited tray cable shall be used where runs are to be in cable tray as shown on the drawings.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. As far as practical, all circuits shall be continuous from origin to termination without splices in intermediate pull boxes. Sufficient slack shall be left at the termination to make proper connections. In no case shall a splice be pulled into the conduit. Conductor splicing shall not be permitted without the Engineer's approval. Conductor splices shall not be made in underground junction boxes or manholes unless specifically noted on the plans.

C. Each feeder and branch circuit shall be installed in its own individual conduit unless combining feeder and branch circuits is permitted as defined in the following:

1. As specifically indicated on the Plans.
2. For lighting, multiple branch circuits may be installed in a conduit as allowed by the NEC and with the wire ampacity de-rated in accordance with the requirements of the NEC. Conduit fill shall not exceed the limits established by the NEC.
3. When field conditions dictate and written permission is obtained from the Engineer.

D. Use manufacturer-approved pulling compound or lubricant when pulling conductors; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

E. Feeder and branch circuits shall be isolated from each other and from all instrumentation and control circuits.

F. Control circuits shall be isolated from all other feeder, branch and instrumentation circuits, except as noted above. 12VDC, 24VDC and 48VDC control circuits may be combined into one conduit. 120/208/240VAC control circuits shall be isolated from all DC control circuits. 277/480VAC circuits shall be isolated from all other voltages.

G. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.

H. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

I. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

J. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems".

K. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems".

L. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

M. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.

N. Wiring at Outlets and Switches: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling".

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping".

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.

    a. All conductors with voltages at 277V or higher and corresponding neutrals and grounds.

    b. All conductors #8 and larger.
    c. All motor leads and corresponding grounds.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Instrumentation cabling.
2. Low-voltage control cabling.
3. Control-circuit conductors.
4. Identification products.

B. Related Sections

1. For structured cabling systems, including fiber optic cabling and CAT6 cabling refer to Section 409533.

1.2 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of an NRTL.

B. 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.

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.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

B. Test each pair of each cable for open and short circuits.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Conduit and Boxes: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

2.2 INSTRUMENTATION CABLE

A. Instrument cable shall be Type TC and/or Belden grey TSP, and have the number of individually shielded twisted pairs indicated on the Plans and shall be insulated for not less than 600 volts. Unless otherwise indicated, conductor size shall be No. 18 AWG minimum. Shielded, grounded instrumentation cable shall be used for all analog and low voltage digital signals.

B. The jacket shall be flame retardant with 90 degrees C temperature rating. The cable shield shall be a minimum of 2.3 mil aluminum or copper tape overlapped to provide 100 percent coverage and a tinned copper drain wire.

C. The conductors shall be tin-plated, soft annealed copper, Class B, 7 strand minimum concentric lay with 15 mils nominal thickness, nylon jacket, 4 mil nominal thickness, 90 degrees C temperature rating. One conductor within each pair shall be numerically identified.

D. Pairs shall be assembled with a nominal 2-inch lay and shall then be group shielded with a minimum of 1.3 mil aluminum or copper tape overlapped to provide 100 percent coverage. All group shields shall be completely isolated from each other.

E. Pairs installed in a cable tray shall have a UV resistant jacket, and shall have a jacket intended for cable tray use.

2.3 RS-232 CABLE

A. Standard Cable: NFPA 70, Type CM.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.

2. Polypropylene insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. PVC jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.4 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM.

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.5 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

C. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

D. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Plastic jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.6 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded tin-plated copper, Type THHN-THWN, in raceway, complying with UL 83.

B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, complying with UL 83.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

2.7 IDENTIFICATION PRODUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Panduit Corp.
3. Or Approved Equal.

B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Comply with requirements in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

B. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for installation of conduits and wireways.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Pathway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 12 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 24 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 48 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 6 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: 3 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

5. Separation between Cables and Electrical Motors and Transformers: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 6 inches.

3.3 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. For data communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 260523

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Grounding systems and equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Stranded Conductors: ASTM B 8.
2. Tinned Conductors: ASTM B 33.
3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad; 3/4 inch in diameter and 10 feet long.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install stranded conductors all conductor sizes.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum. Bury at least 24 inches below grade.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded or approved compression connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.

2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.

1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems", and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least two test wells for each service unless otherwise indicated. Install at the ground rods electrically closest to service entrance. Set top of test well flush with finished grade or floor.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 LABELING

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Make tests at ground rods before any conductors are connected.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.3 ACTION SUBMITTALS

A. Product Data: For steel slotted support systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Equipment supports.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.; a division of Cooper Industries.
    c. ERICO International Corporation.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut; Tyco International, Ltd.
    g. Wesanco, Inc.

3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
6. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

    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) Hilti Inc.
        2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

    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) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti Inc.
        4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.

2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi 20.7-MPa, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in civil specifications.

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

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 minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish and install conduits as required, and as shown on the Plans. Materials employed shall be as shown on the Plans.

1.2 SUBMITTALS

A. Submit product literature including manufacturer part number, model number, material, size, and specifications. Material shall not be installed until the Engineer has reviewed the submittal data.

B. If changes from the Plan are proposed, shop drawings shall be submitted for review and acceptance showing routing, conduit size, and number and size of wires in each conduit before installation of conduit and any related work.

C. Proposed routing of conduits buried under floor slabs-on-grade.

D. Identify conduit by tag number of equipment served or by circuit schedule number.

E. Proposed routing and details of construction including conduit and rebar embedded in floor slabs, columns, etc.

F. Proposed location and details of construction for openings in slabs and walls for raceway runs.

G. Refer to Section 26000 “General Electrical Requirements” for further submittal requirements.

1.3 REFERENCES

A. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc-Coated.

B. National Electric Manufacturers Association (NEMA): RN-1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit.

C. Underwriters Laboratories Inc. (UL):

1. 1, Flexible Metal Conduit.
2. 6, Rigid Metal Conduit.
3. 360, Liquid-Tight Flexible Steel Conduit.
4. 467, Grounding and Bonding Equipment.
5. 514, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers.
6. 651, Schedule 40 and 80 Rigid PVC Conduit.

7. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
8. 884, Underfloor Raceways and Fittings.
9. 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

PART 2 - PRODUCTS

2.1 RACEWAYS

A. Exposed conduits in an unclassified or non-hazardous area shall be Galvanized Rigid Steel (GRS) unless specifically indicated otherwise on the Plans. Conduits in corrosive, hazardous, or damp areas shall be PVC coated GRS unless otherwise indicated. Underground and/or concrete encased conduits shall be PVC, unless otherwise indicated. All conduits concealed in block walls or steel framing shall be EMT with compression fittings unless otherwise indicated. Set screw type fittings in EMT conduit will not be accepted. All wiring, except as otherwise noted, shall be in conduit. Conduit size shall not be less than the National Electrical Code (NEC) size required for the conductors therein and shall not be smaller than 3/4-inch. No underground conduit shall be less than one inch.

B. Condulets type fittings shall be Crouse-Hinds, Appleton, or equal with wedge nut covers. All condulets located outdoors, damp or wet locations shall be weather tight.

C. In unclassified areas, flexible conduit shall be grounding type, weatherproof, corrosion resistant, and watertight.

D. Couplings, connectors, and fittings shall be standard types specifically designed and manufactured for the purpose. They shall be installed to provide a firm mechanical assembly and electrical conductivity throughout. Conduit systems shall be water tight.

E. Expansion fittings shall be OZ type AX with jumper for exposed locations and type DX at structural expansion joints, Spring City, or equal. Conduits shall have expansion fittings in accordance with NEC.

F. The conduits and fittings shall be supported per NEC requirements as a minimum.

G. Sealing fittings shall be provided for classified areas per the NEC requirements in hazardous or corrosive areas. Fittings shall be poured after the final walk-thru unless otherwise directed in writing by the engineer.

2.2 GALVANIZED RIGID STEEL (GRS)

A. Conduits and couplings shall be hot-dipped galvanized with zinc coated threads and outer coating of zinc bichromate, in accordance with ANSI C80.1 standards, as manufactured by Jones & Laughlin Steel Corporation, Allied Tube & Conduit Corporation, Triangle PWC, or equal.

B. Steel conduit shall not be buried in earth without concrete encasement and additional corrosion protection. Instead buried steel conduit shall be PVC coated.

2.3 PVC COATED GALVANIZED RIGID STEEL (PVC-GRS)

A. PVC coated GRS conduit shall be installed where shown on the Plans or elsewhere specified and shall conform to NEMA RN-1 and ANSI C80.1 standards.

B. The zinc surface of the conduit shall remain intact and undisturbed on both the inside and the outside of the conduit throughout the preparation and application processing. A Polyvinyl Chloride (PVC) coating shall be bonded to the galvanized outer surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic. The thickness of the PVC coating shall be a minimum of 0.040-inch (40 mil).

C. A loose coupling shall be furnished with each length of conduit. A PVC coating shall be bonded to the outer surface of the coupling and a PVC sleeve equal to the outside diameter of the uncoated conduit shall extend beyond both ends of the coupling approximately one pipe diameter or 1-1/2 inches, whichever is smaller. The wall thickness of the coating on the coupling and the sleeve shall be a minimum of 0.055-inch (55 mil).

D. A PVC coating shall be bonded to the inner and outer surface of all conduit bodies and fittings and a PVC sleeve shall extend from all hubs. The wall thickness of the coating on conduit bodies and fittings and the sleeve walls shall be identical to those on couplings in length and thickness. The covers on all conduit bodies shall be coated on both sides and shall be designed to be completely interchangeable. The inside of conduit bodies shall remain undisturbed in the processing.

E. Type 304 stainless steel screws shall be furnished and used to attach the cover to the conduit body. All coated material shall be installed and patched according to the manufacturer's recommended installation and patching instructions.

F. Conduit straps shall be PVC coated or stainless steel.

G. PVC coated conduits and fittings shall be as manufactured by Kor Kap Corporation, Occidental Coating Company, Rob-Roy, or equal.

H. PVC coated flexible conduits shall be liquid and vapor-tight and manufactured in accordance with UL 360 standards.

2.4 RIGID NONMETALLIC – PVC

A. Where specifically indicated on the Plans, or elsewhere specified, conduit may be high density Schedule 40, 90 degrees C, heavy-duty PVC. The conduit shall be manufactured from virgin polyvinyl chloride compound which meets ASTM D1784, NEMA TC-2, ANSI C33.91, and UL 651 standards. Smoke emissions shall be limited to less than 6 grams per 100 grams of material tested.

B. Where conduit concrete encasement is indicated on the Plans, conduit supports shall be installed at five-foot intervals. PVC conduit shall be manufactured by Carlon, Triangle Conduit & Cable, or equal.

2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Liquidtight flexible metal conduit shall be liquid and vapor-tight, oil and ultraviolet ray resistant and manufactured in accordance with UL 360 standards. Liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, galvanized steel core with an extruded PVC jacket. The PVC jacket shall be rated for high ambient heat applications, 90 degrees Celsius.

B. For corrosive locations, liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, aluminum core with an extruded PVC jacket. The PVC jacket shall be impervious to corrosive liquids and vapors and PVC coated fittings shall be utilized.

C. An external bonding conductor shall be required for flexible conduit connections containing circuits rated at 60 amps or greater and for sizes 1 1/2 " or larger. Flexible conduits and connectors for 1 1/4 " and smaller shall be listed for grounding.

D. For non-corrosive locations, connectors for liquidtight flexible conduit shall be hot-dipped galvanized, furnished with a sealing ring and locknut, and suitable for wet locations.

E. For systems utilizing corrosive locations, connectors shall be galvanized PVC coated.

2.6 ELECTRICAL METALLIC TUBING (EMT)

A. Per UL Standard for Electrical Metallic Tubing No. 797. Galvanized mild steel with interior coat of enamel.

B. Fittings shall be steel set-screw type. Cast type, indenter type or compression steel fittings are not acceptable.

C. Approved for plan specified locations only. Approved for conduits concealed in block walls and concealed in steel framed walls. Not approved for process areas where wash down or high humidity conditions exist.

2.7 ALUMINUM CONDUIT

A. Aluminum conduit is approved for wet and corrosive areas only. Prior approval from the engineer must be obtained when substituting for PVC coated.

B. Aluminum hardware and conduit shall be isolated from all dissimilar materials as appropriate.

1. Isolation from dissimilar metals in channel or support by a single layer of scotch #33+ or approved equal.
2. Isolation from concrete shall be by neoprene gaskets.
3. Aluminum shall not be used for concrete penetrations.

C. Aluminum conduit shall contain less than 0.4% copper.

2.8 STAINLESS STEEL CONDUIT

A. Stainless Steel Conduit conduit is approved for all exposed conduit locations. Prior approval from the engineer must be obtained when substituting for PVC coated.

B. Stainless Steel conduit and all fittings and support hardware shall be 316 SS.

2.9 CABLE TRAY SYSTEM

A. Provide cable tray systems composed of straight sections, fittings, and accessories as defined in the latest NEMA Standards publication VE-1 - Ventilated Cable Tray.

1. Provide cable trays and fittings shall constructed of materials suited for the area classification as noted below.
2. Provide cable trays shall be of the ladder type with availability of 6, 9, and 12-inch spacing.
3. Provide tray sizes with a 3, 4, 5, or 6-inch minimum usable load depth, as indicated on the drawings.
4. Provide loading capacities that meet the NEMA weight classification with a safety factor of 1.5.
5. In corrosive, damp, or Hazardous locations, provide cable trays manufactured of aluminum.
6. In non-classified areas provide cable trays manufactured of Hot Dipped galvanized materials. All cuts and welds shall be touched up with cold galvanizing spray per the raceway specification.
7. Separate power, control, signal and communications cables by grounded metallic dividers or run in separate trays.
8. Manufacturer, or Approved Equal

    a. Husky
    b. B-Line
    c. T.J. Cope

PART 3 - EXECUTION

3.1 INSTALLATION

A. Conduit runs are schematic only, and shall be modified as required to suit field conditions, subject to review and acceptance by the Engineer.

B. Conduit shall run continuously between outlets and shall be provided with junction boxes where connections are made. Couplings, connectors, and fittings shall be acceptable types designed and manufactured for the purpose, and shall provide a firm mechanical assembly, and electrical conductivity throughout.

C. Conduit runs shall be straight and true. Elbows, offsets, and bends shall be uniform and symmetrical. Changes in direction shall be made with long radius bends, or with fittings of the condulet type.

D. Conduit runs in buildings and structures shall be concealed where possible except as specifically noted, or accepted by the Engineer.

E. Conduit runs shall not interfere with the proper and safe operation of equipment, and shall not block or interfere with ingress or egress, including equipment removal hatches.

F. Exposed conduits shall be securely fastened with clamps, or straps, intended for conduit use. All exposed conduit shall be run on the walls and ceiling only and shall be parallel to the planes of the walls or ceiling. No diagonal runs will be permitted. Flexible conduit shall be used only for short lengths required to facilitate connections between rigid conduit to vibrating equipment such as motors, fans, and transformers. The maximum length of flexible conduit shall be 3 feet, unless approved in writing by engineer. Flexible conduit shall not be used for electrician's convenience where rigid conduit could be used.

G. Conduit runs on water-bearing walls shall be supported one inch away from the wall on an accepted channel. When channel galvanizing, or other coating, is cut or otherwise damaged, it shall be field coated to original condition. No conduit shall be run in water-bearing walls, unless specifically designated otherwise.

H. Conduit shall be thoroughly reamed to remove burrs. IMC or GRS shall be reamed during the threading process, and Rigid Nonmetallic PVC shall be reamed before applying fittings. A zinc rich cold galvanizing shall be used to restore corrosion protection on field cut threads.

I. Bushings and lock nuts or hubs shall be used at conduit terminations. Conduit, bushings, locknuts, and enclosures shall be fastened to the conduit system prior to pulling wire. Splitting the bushings for installation will not be accepted. Hubs shall be used in all process areas outside of electrical rooms unless otherwise specified. The total number of bends in any run between pull points shall not exceed 360 degrees. Junction boxes and pull boxes shall be installed at points acceptable to the Engineer. Conduit ends shall be plugged to prevent the entrance of moisture or debris during construction. All spare conduits shall be adequately capped and shall contain a suitable pull string. Splices shall be made in junction boxes only. Splices in conduit bodies will not be accepted.

J. Joints shall be set up tight. Hangers and fastenings shall be secure, and of a type appropriate in design, and dimensions, for the particular application.

K. Conduit runs shall be cleaned and internally sized (obstruction tested) so that no foreign objects, or obstructions remain in the conduit prior to pulling in conductors.

L. After installation of complete conduit runs 2 inches and larger, conduits shall be snaked with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of the nominal diameter of the conduit. Conduits through which the mandrel will not pass shall not be used. Test results should be submitted to the engineer.

M. Expansion fittings shall be installed across all expansion joints and at other locations where necessary to compensate for thermal expansion and contraction.

N. Provide trenching, backfill, and compaction for conduits installed underground.

O. Raceways running parallel to hot water or steam piping shall maintain a distance of 6 inches from the piping.

P. Raceways crossing steam or liquid filling piping shall cross above the piping.

Q. In slab conduits, shall be covered by a minimum of 2 inches of concrete.

R. Conduits of the same duty (480V Power, 120V Power, 120V Controls and signals) shall have a minimum separation of 2 inches between conduits.

S. Conduits and raceways carrying signal wiring shall have a minimum separation of 12 inches from 480V power raceways, 6 inches from 120V power raceways, and 4 inches from 120V control raceways.

T. Raceways with 120V Control shall maintain a distance of 12 inches from 480V power raceways, 6 inches from 120V power raceways.

U. Raceways with 120V power shall maintain a distance of 6 inches from 480V power raceways.

3.2 CABLE TRAYS

A. Provide cable trays in strict accordance with the manufacturer's printed instructions.

B. Allowable cable fill areas shall meet NEC Article 392 - Cable Trays requirements.

C. Verify cable tray fills prior to installation based on cables and trays actually provided.

D. Maintain continuous grounding of cable trays including bonding jumpers in accordance with the requirements of NEC Article 392.

E. Install cable trays using hangers and supports on 8-foot centers, maximum.

F. Install cable trays to walls as the primary method of support where possible.

G. If support from the ceiling is the only alternative, use hangers and supports on 6-foot centers, maximum.

H. Ensure that proper separation between duties as detailed in 3.1.

END OF SECTION 260533

SECTION 260534 – ENCLOSURES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This specification includes enclosures to house electrical controls, instruments, terminal blocks, and serve as junction boxes where shown on the Drawings.

1.2 RELATED SECTIONS

A. For Raceways and Boxes for Electrical Systems see Section 260533 “Raceways and Boxes for Electrical Systems”.

1.3 SUBMITTALS

A. Products shall be submitted in accordance with Section 26000 “General Electrical Requirements”, and elsewhere in the Contract Documents, prior to installation.

1.4 MANUFACTURERS

A. Enclosures shall be manufactured by Hoffman, Rittal, or equal.

PART 2 - PRODUCTS

2.1 STEEL

A. Enclosures shall be fabricated from 14-gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.

B. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be of stainless steel for outdoor installations. A hasp and staple shall be provided for padlocking. Each enclosure shall have a print pocket. All wires entering or leaving the enclosure shall terminate on terminal strips. All wires and terminals shall be clearly identified as specified elsewhere in these specifications.

C. Finish shall be white enamel interior, light gray enamel, ANSI 61 exterior, over phosphatized surfaces. Special finishes and colors shall be furnished for wet locations. Plans should be checked for special conditions.

2.2 NEMA RATING

A. Unless otherwise indicated on the Plans, enclosures shall be NEMA 12 for indoors, NEMA 4X for corrosive areas, and NEMA 4 for outdoor installations. NEMA 4X enclosures shall be stainless steel, unless noted otherwise. NEMA 4X enclosures shall also be used in wet, or wash down areas.

B. All enclosures used in classified areas shall be NEMA 7.

C. In Waste Water facilities, all enclosures in process areas shall be NEMA 4X stainless steel. Enclosures in electrical rooms, meeting rooms, offices and shops shall be NEMA 12 unless otherwise specified.

D. Areas not specified in Water Treatment, Wastewater, or other water related facilities shall be approved by the engineer for NEMA type prior to installation.

2.3 FIBERGLASS

A. Enclosures shall be heavy-duty, compression molded, fiberglass reinforced polyester, high impact, heat resistant, NEMA 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Enclosures shall be installed as indicated on the Plans, and according to manufacturer's instructions.

B. Enclosures shall be properly grounded, and shall include ground straps connected to hinged doors and accessories.

END OF SECTION 260534

SECTION 260543 – UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Conduit, ducts, and duct accessories for concrete-encased duct banks.
2. Handholes and boxes.
3. Manholes.

B. Related Requirements:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For accessories for handholes and boxes.

B. Shop Drawings for Factory-Fabricated Handholes and Boxes: Include dimensioned plans, sections, elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.
4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
4. CertainTeed Corp.; Pipe & Plastics Group.
5. Condux International, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT; a division of Cable Design Technologies.
11. Spiraduct/AFC Cable Systems, Inc.

B. Underground Plastic Utilities Duct: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

C. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 76 mm) in size, manufactured from 6000-psi (41-MPa) concrete.

    a. Color: Red dye added to concrete during batching.
    b. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

2.3 HANDHOLES AND BOXES

A. Description: Comply with SCTE 77.

1. Color: Gray or Green, depending on location.
2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC."
6. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.
    c. Christy Concrete Products.
    d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "General Earthwork," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Resto-revegetation and include necessary top-soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants and Planting."

D. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.2 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward handholes and away from buildings and equipment.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations, unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to handhole.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

G. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Concreting Sequence: Pour each run of envelope between terminations in one continuous operation.

    a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle,

uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 3 inches between ducts for like services, and 6 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 24 inches below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
8. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
9. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.
    b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

10. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

I. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Section 312000 "General Earthwork" for pipes less than 6 inches in nominal diameter.
4. Install backfill as specified in Section 312000 " General Earthwork."
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections

at end of run and complete backfilling with normal compaction as specified in Section 312000 " General Earthwork."

6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 24 inches below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.
    b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

11. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of duct bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

3.3 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below the frost line.

E. 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 the enclosure.

F. Field-cut openings for ducts and 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.

3.4 GROUNDING

A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.6 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 260543

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products 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."

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

    a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
    b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Advance Products & Systems, Inc.
    b. CALPICO, Inc.
    c. Metraflex Company (The).
    d. Pipeline Seal and Insulator, Inc.
    e. Proco Products, Inc.

3. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
4. Pressure Plates: Stainless steel.
5. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Presealed Systems.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall have VOC content of 100 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. 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."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

    a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
    b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using **steel** pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 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.

END OF SECTION 260544

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Channel support systems.
   2. Restraint cables.
   3. Hanger rod stiffeners.
   4. Anchorage bushings and washers.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

   1. Site class, building code and Design Spectral Response Acceleration as defined on the Contract Drawings.

1.3 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. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For 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 and seismic restraints.

a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other electrical Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
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.
   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).

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

C. 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.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
6. Mason Industries.
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements 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: 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.

D. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.

E. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

F. 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.

G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

H. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

I. Adhesive Anchor: 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.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables 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 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.
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.

B. 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.

C. 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.

D. 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 runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Obtain Engineer's approval before transmitting test loads to structure. Provide temporary load-spreading members.
2. Test at least four of each type and size of installed anchors and fasteners selected by Engineer.
3. Test to 90 percent of rated proof load of device.
4. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples of each color, lettering style and other graphic representation required for each identification material or system.

C. Table or list of equipment, panel and disconnect switch labels.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Write-On Tags shall not be allowed.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label. Heat shrink tubing, or sleeve type wire markers are also acceptable.

A. Write-On Tags shall not be allowed.

B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

C. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label. Heat shrink tubing, or sleeve type wire markers are also acceptable.

C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

D. Write-On Tags shall not be allowed.

2.5 FLOOR MARKING TAPE

A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.

2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Tag: Type I:

1. Pigmented polyolefin, bright-colored, compounded for direct-burial service.
2. Thickness: 4 mils.
3. Weight: 18.5 lb/1000 sq. ft.
4. 3-Inch Tensile According to ASTM D 882: 30 lbf, and 2500 psi.

D. Tag: Type ID:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, compounded for direct-burial service.
2. Overall Thickness: 5 mils.
3. Foil Core Thickness: 0.35 mil.
4. Weight: 28 lb/1000 sq. ft.
5. 3-Inch Tensile According to ASTM D 882: 70 lbf, and 4600 psi.

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.8 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 CONDUCTOR LABELING SCHEME

A. All control and instrumentation conductors shall be labeled with a "To/From" labeling scheme. Each conductor label shall have two lines of text. The first line of text shall indicate the enclosure and terminal where the wire is to terminate on the other end. The second line of text shall indicate the enclosure and terminal where the wire is to terminate on this end. The following example illustrates the "To/From" labeling scheme:

1. A wire is connected between a VFD and an LCP. The VFD equipment tag is VFD-100 and the LCP equipment tag is LCP-100. The connecting terminal at the VFD enclosure is terminal "5". The connecting terminal at the LCP is terminal "7". This wire would have the following labels:
   a. The wire label at the VFD end:
      Top Line: "LCP-100 : 7"
      Bottom Line: "VFD-100 : 5"
   b. The wire label at the LCP end:
      Top Line: "VFD-100 : 5"
      Bottom Line: "LCP-100 : 7"

3.2 INSTALLATION

A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Apply identification devices to surfaces that require finish after completing finish work.

C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

G. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.3 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120V to ground: Install labels at 10-foot maximum intervals.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:

1. Emergency Power.
2. Power.
3. UPS.

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

a. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

b. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

c. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

a. Power transfer switches.
b. Controls with external control power connections.

J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.

c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION 260553

SECTION 260573 – ELECTRICAL TESTING WITH COORDINATION STUDY

PART 1 – GENERAL

1.1 SCOPE

A. The contractor shall furnish short-circuit and protective device coordination studies as prepared by the electrical equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in NFPA 70E. The arc flash hazard analysis shall be performed according to the IEEE 1583 equations that are presented in NFPA 70E-2004, Annex D.

C. The scope of the studies shall include all new distribution equipment supplied by the equipment Manufacturer under this contract as well as all existing distribution equipment at the customer facility.

D. The contractor shall perform electrical tests as described in Part 3 of this document.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):

   a. 450, Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generator Stations and Substations.
   b. C2, National Electric Safety Code.
   c. C37.13, Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
   d. C37.20.1, Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
   e. C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear.
   f. C37.20.3, Metal-Enclosed Interrupter Switchgear.
   g. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
   h. C62.33, Standard Test Specifications for Varistor Surge Protective Devices.

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

   a. D665, Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
   b. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   c. D923, Standard Test Method for Sampling Electrical Insulating Liquids.
   d. D924, Standard Test Methods for A-Class Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.

e. D971, Standard Test Method for Interfacial Tension of 0.1 against Water by the Ring Method.
f. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
g. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
h. D1500, Standard Test Method for ASTM Color of Petroleum Products.
i. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
j. D1533, Standard Test Methods for Water in Insulating Liquids.
k. D1816, Standard Test Method for Dielectric Breakdown Voltage on Insulating Oils of Petroleum Origin Using VDE Electrodes.
l. D2285, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin against Water by the Drop-Weight Method.

3. Institute of Electrical and Electronics Engineers (IEEE):

a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
b. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators.
c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
d. 95, Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage.
e. 118, Standard Test Code for Resistance Measurement.
f. 141, Recommended Practice for Electric Power Distribution and Coordination of Industrial Power Systems.
g. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
h. 399, Recommended Practice for Industrial and Commercial Power System Analysis
i. 400, Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.
j. 1015, Recommended Practice for Apply Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
k. 1584, Guide for Performing Arc-Flash Hazard Calculations

4. National Electrical Manufacturers Association (NEMA):

a. AB 4, Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
b. PB 2, Deadfront Distribution Switchboards.
c. WC 7, Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
d. WC 8, Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

5. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

6. National Fire Protection Association (NFPA):

    a. 70, National Electrical Code (NEC).
    b. 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

1.3 SUBMITTALS

A. Analysis Studies Submittal: Submit prior to receiving final approval of the distribution equipment submittal and prior to release of equipment manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval may be obtained from the Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report and submitted to the Design Engineer
2. The report shall include the following sections:
    a. Executive Summary
    b. Descriptions, purpose, basis and scope of the study
    c. Tabulations of circuit breaker, fuse and other protective device ratings versus short circuit duties
    d. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trips unit settings, fuse selection
    e. Fault current calculations including a definition of terms and guide for interpretation of the computer printout\
    f. Details of the incident energy and flash protection boundary calculations
    g. Recommendations for system improvements, where needed
    h. One-line diagram
3. Arc flash labels shall be provided in hard copy only
4. Sample copy of individual device test form.
5. Sample copy of individual system test form.

B. Administrative Submittals: Submit 30 days prior to performing inspections or tests:

1. Schedule for performing inspection and tests.
2. List of references to be used for each test.
3. Sample copy of equipment and materials inspection form(s).
4. Sample copy of individual device test form.
5. Sample copy of individual system test form.

C. Quality Control Submittals: Submit within 14 days after completion of test:

1. Test or inspection reports and certificates for each electrical item tested.

D. Contract Closeout Submittals:

1. Operation and Maintenance Data:
   a. In accordance with references elsewhere in these specifications.
   b. After test of inspection reports and certificates have been reviewed by ENGINEER and returned, insert a copy of each in operation and maintenance manual.

1.4 QUALIFICATIONS

A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.

B. The Engineer shall be a full-time employee of the equipment manufacturer or an approved engineering firm.

C. The Engineer shall have a minimum of five (5) years of experience in performing power system studies.

D. The Engineer shall submit references of at least ten actual short-circuit, protective device coordination and arc flash hazard analysis studies performed over the last five years.

1.5 QUALITY ASSURANCE

A. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

B. Test instrument calibration shall be in accordance with NETA ATS.

1.6 SEQUENCING AND SCHEDULING

A. Perform short-circuit, protective device coordination and arc flash hazard analysis studies prior to final approval of distribution equipment submittal

B. Perform inspection and electrical tests after equipment has been installed.

C. Perform tests with apparatus de-energized whenever feasible.

D. Inspection and electrical tests on energized equipment are to be:
1. Scheduled with OWNER prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

E. Notify OWNER at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 – PRODUCTS

2.1 STUDIES

A. Contractor is to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E Article 130.3 and Annex D.

2.2 DATA COLLECTION

A. Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future motors and generators

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor

2.3 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141-1993.

B. Transformer design impedances shall be used when test impedances are not available.

C. Provide the following:
1. Calculation methods and assumptions
2. One-line diagram of the system being evaluated
3. Source impedance data, including utility system and motor fault contribution characteristics
4. Tabulations of calculated quantities
5. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:
1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation
1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
3. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current.

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs

B. Include on each TCC graph, a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

D. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the TCC graphs, where applicable:
1. Electric utility's overcurrent protective device
2. Medium voltage equipment overcurrent relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points, where applicable
9. Pertinent generator short-circuit decrement curve and generator damage point
10. The largest feeder circuit breaker in each motor control center and applicable panelboard

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

2.5 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

C. The Arc-Flash Hazard Analysis shall include all significant locations in 240 volt and 208-volt systems fed from transformers equal to or greater than 125 kVA where work could be performed on energized parts.

D. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

F. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:
   1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
   2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

H. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

2.6 REPORT SECTIONS

A. Input data shall include, but not be limited to the following:
1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).
2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps and phase shift.
3. Reactor data, including voltage rating, and impedance.
4. Generation contribution data, (synchronous generators and Utility), including short-circuit reactance (X"d), rated MVA, rated voltage, three-phase and single line-ground contribution (for Utility sources) and X/R ratio.
5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.

B. Short-Circuit Output Data shall include, but not be limited to the following reports:
1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage
   b. Calculated fault current magnitude and angle
   c. Fault point X/R ratio
   d. Equivalent impedance
2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage
   b. Calculated symmetrical fault current magnitude and angle
   c. Fault point X/R ratio
   d. Calculated asymmetrical fault currents
   e. Equivalent impedance
3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage
   b. Calculated symmetrical fault current magnitude and angle
   c. Fault point X/R ratio
   d. No AC Decrement (NACD) Ratio

e. Equivalent impedance
f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers

C. Recommended Protective Device Settings:
1. Phase and Ground Relays:
a. Current transformer ratio
b. Current setting
c. Time setting
d. Instantaneous setting
e. Recommendations on improved relaying systems, if applicable.
2. Circuit Breakers:
a. Adjustable pickups and time delays (long time, short time, ground)
b. Adjustable time-current characteristic
c. Adjustable instantaneous pickup
d. Recommendations on improved trip systems, if applicable.

D. Incident energy and flash protection boundary calculations
1. Arcing fault magnitude
2. Protective device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category
8. Recommendations for arc flash energy reduction

PART 3 – EXECUTION

3.1 GENERAL

A. Tests specified in this section are to be performed in accordance with the requirements elsewhere in these specifications.

B. Coordination with local Utilities to obtain necessary information to perform the tests specified in this section is the responsibility of the Contractor. All costs incurred in obtaining required information shall be borne by the Contractor.

B. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. All trip units are adjusted to avoid erroneous tripping of circuit breakers.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, and ANSI C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Adjust mechanisms and moving parts for free mechanical movement.

E. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

F. Verify nameplate data for conformance to Contract Documents.

G. Realign equipment not properly aligned and correct un-levelness.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Provide proper lubrication of applicable moving parts.

L. Inform OWNER of working clearances not in accordance with NFPA 70.

M. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

N. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by OWNER, door and panel sections having dented surfaces.
5. Repair or replace, as determined by OWNER, poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
    a. Provide matching paint and touch up scratches and mars.
    b. If required due to extensive damage, as determined by OWNER, refinish the entire assembly.

O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents.

3.2 COORDINATION STUDY FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

3.3 ARC FLASH WARNING LABELS

A. The contractor of the Arc Flash Hazard Analysis shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.

C. The label shall include the following information, at a minimum:
1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Hazard risk category
5. Incident energy
6. Working distance

D. Labels shall be machine printed, with no field markings.

E. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
1. For each 600, 480 and applicable 208-volt panelboard, one arc flash label shall be provided.
2. For each motor control center, one arc flash label shall be provided.
3. For each low voltage switchboard, one arc flash label shall be provided.
4. For each switchgear, one flash label shall be provided.
5. For medium voltage switches one arc flash label shall be provided

3.4 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect Each Individual Exposed Power Cable No. 4 and Larger For:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends that do not conform with manufacturer's minimum allowable bending radius where applicable.
   d. Color coding conformance with specifications.
   e. Proper circuit identification.
2. Mechanical Connections For:

a. Proper lug type for conductor material.
b. Proper lug installation.
c. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.

3. Shielded Instrumentation Cables For:
   a. Proper Shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4 Control Cables For:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohm-meter dc voltage in accordance with NETA ATS, Table 10.2.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than ohm values established by manufacturer.
   d. Provide test reports to Engineer and Owner that show where test measurements were taken and the results
2. Contact Resistance Tests:
   a. Contact resistance in micro-ohms across each switch blade and fuse holder.
   b. Investigate deviation of 50% or more form adjacent poles or similar switches.

3.5 MOLDED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 400 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 10.1.
6. Operate frame size and trip setting with circuit breaker schedules or one-line diagram.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohm-meter for 480- and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.

c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
d. Test values to comply with NETA ATS, Table 10.2.

2. Contact Resistance Tests:
   a. Contact resistance in micro-ohms across each pole.
   b. Investigate deviation of 50% or more from adjacent poles and similar breakers.
3. Trip Coordination Study:
   a. Provide coordination study of all new and existing equipment in the facility.
   b. Adjust all circuit breaker settings per the coordination study.

3.6 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually Check Current, Potential, and Control Transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections
   d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically that:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 7.1.1.

3.7 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify that meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.8 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control centers and panelboards assemblies for proper connection and tightness.
2. Ground bus connections in motor control centers and panelboards assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled, and proper bonding was obtained.

6. Test ground system using 3-point fall of potential test equipment. Ground system must provide less than 5 ohms to ground resistance. Provide test reports to Engineer and Owner that show where test measurements were taken and the results. System must be tested at all ground rods, concrete encased electrodes, ground busses and service entrance locations.

3.9 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 10 hp and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate Motor and Check for:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for proper operation.
   e. Excessive vibration.
5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 10.2 for:
      1) Motors above 200 hp for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      2) Motors 200 hp and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.
   b. Insulation resistance values equal to, or greater than, ohm values established by manufacturers.
2. Calculate polarization index ratios for motors above 200 hp. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
4. Measure running current and voltage and evaluate relative to load conditions and nameplate full-load amperes.
5. Provide test reports to Engineer and Owner that show where test measurements were taken and the results

3.10 LOW VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of draw out elements.
6. Integrity and contamination of us insulation system.
7. Check Door and Device Interlocking System By:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check Nameplates for Proper Identification Of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbuttons.
    c. Control switches.
    d. Pilot lights.
    e. Control relays.
    f. Circuit breakers.
    g. Indicating meters.
9. Verify that fuse and circuit breaker sizes and types conform to Contract Documents.
10. Verify that current and potential transformer ratios conform to Contract Documents.
11. Check Bus Connections for High Resistance by Low Resistance Ohmmeter and Calibrated Torque Wrench Applied to Bolted Joints:
    a. Ohm value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
12. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
13. Verify performance of each control device and feature furnished as part of the motor control center.
14. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
15. Exercise active components.
16. Inspect Contactors For:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of all connections.
17. Compare overload heater rating with full-load current for proper size.
18. Compare fuse, motor protector, and circuit breaker with motor characteristics for proper size.
19. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohm-meter dc voltage in accordance with NETA ATS, Table 10.2.
   b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
   c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
   d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
   e. Test values to comply with NETA ATS, Table 10.2.
2. Current Injection through Overload Unit at 300% of Motor Full-Load Current and Monitor Trip Time:
   a. Trip time in accordance with manufacturer's published data.
   b. Investigate values in excess of 120 seconds.
3. Control Wiring Tests:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards and each device terminal.
   c. Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid state components.
      1) Insulation resistance to be 1 megohm minimum.
4. Operational test by initiating control devices to affect proper operation.
5. Provide test reports to Engineer and Owner that show where test measurements were taken and the results

END OF SECTION 260753

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.
2. Buck-boost transformers.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated.

B. Shop Drawings: Indicate dimensions and weights.

1. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

B. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 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. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ACME Electric Corporation; Power Distribution Products Division.
2. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
3. Controlled Power Company.
4. Eaton Electrical Inc.; Cutler-Hammer Products.
5. Federal Pacific Transformer Company; Division of Electro-Mechanical Corp.
6. General Electric Company.
7. Hammond Co.; Matra Electric, Inc.
8. Magnetek Power Electronics Group.
9. Micron Industries Corp.
10. Myers Power Products, Inc.
11. Siemens Energy & Automation, Inc.
12. Sola/Hevi-Duty.
13. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Enclosure: Ventilated, NEMA 250, Type 3R.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

F. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity

I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

J. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

M. Wall Brackets: Manufacturer's standard brackets.

2.4 BUCK-BOOST TRANSFORMERS

A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.

B. Enclosure: Ventilated, NEMA 250, Type 2.

1. Finish Color: Gray.

2.5 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Brace wall-mounting transformers as specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

    a. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
    b. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
    c. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

3.3 ADJUSTING

A. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

END OF SECTION 262200

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section covers electrical panelboards.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 26 00 00, and the Contract Documents, prior to installation.

B. Panel layout with alphanumeric designation, branch circuit breaker sizes and types, AIC rating, bus sizes, bus material and other characteristics.

1.3 QUALITY ASSURANCE

A. NEMA PB-1, Panelboards

B. NEC

C. UL67, Panelboards

PART 2 - PRODUCTS

2.1 PANELBOARDS

A. Dead-front panelboards, including lighting distribution and control panels, shall be furnished and installed as indicated on the Plans. Buses shall be tin-plated copper. If shown on the drawings as 4 wire, neutral shall be 100% rated. Mounting and type of enclosures shall be as indicated on the Plans. Where not indicated, indoor enclosures shall be NEMA 12 and outdoor enclosures shall be NEMA 4. The minimum interrupting capacity of any device shall be 22 KAIC unless otherwise indicated on the Plans.

B. All lighting panels shall have surge protection devices.

C. Protective devices shall be replaceable without disturbing adjacent units and shall be of the bolt-on type. Snap in protective devices will not be accepted. Wire connectors shall be suitable for wire sizes indicated. Branch circuits shall be numbered as indicated on the Plans, and a complete typed circuit schedule shall be furnished under a transparent cover and affixed to the inside of the panel access door. Phase busing shall be full height without reduction. Full size neutral and ground bars shall be included and shall have suitable lugs for each outgoing circuit requiring connection. Spaces for future protective devices provided in lighting panels shall be bused for the maximum device that can be fitted into them.

D. Panelboards shall be finished with a primer, rust resistant phosphate undercoat and two coats of oven baked enamel with finish ANSI grey. They shall be sized to provide a minimum of 4 inches of gutter space on all sides. Doors shall not uncover any live parts and shall be hinged and have latches that require no tool to operate. Panelboard doors shall be lockable. Lock and two keys shall be furnished.

E. Each panelboard shall have, on the outside of the door, a lamicoid nameplate with ¾-inch letters as specified elsewhere in these Contract Documents.

F. Panelboards shall be as manufactured by Square D, General Electric, Eaton / Cutler Hammer, or equal.

G. Panelboards shall be service entrance rated where required, and as shown on the Plans.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Panelboards shall be installed as indicated on the plans and according to manufacturer's instructions.

B. Provide grounding per NEC, and Section 260526.

C. Contractor shall verify all NEC clearance requirements prior to installation.

END OF SECTION 262416

SECTION 262419 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The Contractor shall furnish and install, ready to use, motor control centers for use as indicated on the Contract Drawings and specified herein.

B. Circuit breaker ratings, and modifications, shall be as indicated on the Contract Drawings.

C. MCP ratings, and modification, shall be as indicated on the Contract Drawings.

1.2 SUBMITTALS

A. The motor control centers shall meet the requirements of the latest edition of Standards for Industrial Control No. ICS published by the National Electrical Manufacturers Association. The following minimum information and drawings shall be submitted for review:

1. Plan, front, side views and overall dimension of each motor control center.
2. Weight.
3. Internal wiring diagram of each plug-in unit.
4. Internal wiring diagram of the motor control centers.
5. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
6. One-line and schematic diagram for each motor control center.
7. Bill of material list and Manufacturer's Product Data.
8. Installation instructions including seismic installation.
9. Manufacturer's certification that the following items are capable of interrupting and/or withstanding the specified short circuit condition:
    a. Bus bar bracing
    b. Feeder tap units
    c. Starter units

B. Product information shall be submitted in accordance with Section 26 00 00 “General Electrical Requirements”, and elsewhere in the Contract Documents.

PART 2 - PRODUCTS

2.1 MOTOR CONTROL CENTERS (MCC)

A. The motor control center fabricator shall be the manufacturer of the major components therein, such as circuit breakers and starters. Engineered motor control centers shall be by the component and housing manufacturer. The manufacturer shall comply with equipment specifications contained elsewhere in these Contract Documents.

B. Each component, as well as the complete assembly, shall be constructed and tested in accordance with latest NEMA Standards for Industrial Control. The type of construction of the control centers shall be NEMA Class II, Type B. Lifting eyes shall be provided on each section to facilitate handling.

C. Unit doors shall be mounted on the stationary structure and hinged on the side away from the vertical wireway. They shall be held closed with slotted thumbscrews.

D. Unit doors shall have positive action linkage with disconnect operating mechanism. Mechanism shall be designed so that it can be locked in the OFF position with up to 3 padlocks. When the handle is not padlocked, it shall be possible to open the door by releasing the door interlock with a small screwdriver. The control units shall be of the plug-in type. When doors are closed, the operating mechanism shall clearly indicate the ON or OFF position of the disconnect, and the door interlock mechanism shall engage. The disconnect operating mechanism shall be designed against inadvertent operation when the door is open. Each plug-in unit door shall be provided with a nameplate, specified elsewhere herein, that indicates the circuit number and circuit name. The nameplate shall be attached to the door with stainless steel screws. Each motor starter door shall be provided with an externally operated manual reset pushbutton for the overload relay.

E. It shall be possible to install up to 6 NEMA size one units in one vertical section. Units shall be completely enclosed with sheet steel. A small wireway shall be provided inside the unit, so all wiring can be laid in place without removing barriers or plates. Each vertical section that holds the units shall be rigidly formed of minimum 12 gauge, cold-rolled sheet steel. The vertical front-of-board-construction shall be supplied with minimum 20-inch depth.

F. Continuous horizontal wiring troughs shall be provided at both top and bottom of each section. These troughs shall line up to form a continuous wireway for the full length of the MCC. A large continuous, full-height vertical wiring trough shall be provided in the right side of each section.

G. All starter wiring, control, and power shall be terminated in terminal strips in this trough for size 2 and smaller starters. Size 3 and larger starters shall have control leads terminating on the terminal strips in the trough. Terminal strips shall be split-type to facilitate wiring connections without disconnecting factory or field conductors. Terminal strips shall be rated to accept conductor sizes as indicated on the Contract Drawings.

H. All bus bars shall be tin plated copper, and shall be of the ampacity indicated on the Contract Drawings. Unit bus bar stabs shall insure high contact pressure. The vertical bus bars shall be effectively isolated from accidental contact by plastic insulating medium.

I. Bus bar supports shall be of high impact strength non-carbonizing insulating material mounted on padded steel brackets and shall provide adequate dielectric strength and creepage distance. The bus structure shall be capable of withstanding short circuit current in accordance with NEMA standards, and as indicated on the Contract Drawings.

J. Each section shall be equipped with horizontal ground bus that shall be continuous across the MCC.

K. The MCCs shall be supplied as indicated on the Contract Drawings, and as specified herein and in accordance with NEMA Standard Pub. IS 1.1, latest edition. The MCCs shall be enclosed in NEMA Type 1 gasketed industrial use enclosures, unless otherwise shown. NEMA 3R enclosures shall provide sufficient depth for air conditioning units to be mounted on the end of the structures. If the MCCs contain VFDs or Solid State Starters that require cooling, their respective sections shall be louvered top and bottom, and fans shall remove heat from within the sections.

L. All metal surfaces and structural parts shall be given a phosphatizing, or equal, treatment prior to painting. The control centers shall then be given a gun-metal gray undercoat which is equal to zinc chromate. The exterior of the enclosure shall be finished in standard ANSI Grey.

M. Spaces for future combination starters shall have all the hardware necessary so that a future plug-in control unit can be installed without having to modify the vertical sections. The number of spaces for future control units shall be as indicated on the Contract Drawings.

N. Devices, such as, but not limited to, starters, circuit breaker, relays, timers, conductors, shall conform to other sections of these Contract Documents.

O. Provide customer metering instruments, as indicated on the Contract Drawings. Unless otherwise indicated on the Contract Drawings, metering units shall be electronic, capable of displaying volts line-to-line and line-to-neutral, and amps per phase.

P. Each section shall be equipped with horizontal neutral bus that shall be continuous across the MCC if the MCC is designated as 277/480 volt 4 wire.

Q. MCCs for this project shall be an intelligent MCC assembly with smart starters and VFD's each with an Ethernet port and support for monitoring and control over the Ethernet/IP protocol. Due to the variance in methods for implementing smart starters and VFDs, the schematics shown in the Contract Drawings shall be used as a guide in developing the actual schematics based upon actual vendor information. Each intelligent MCC shall be equipped with Layer 2 managed switches powered by a redundant DC power supply system. The connection from the plant SCADA network to the MCC shall be from a single CAT6 connection. Provide a minimum of four spare copper Ethernet ports for future connections.

Q. MCCs shall be as manufactured by Allen-Bradley, Eaton or Square D.

PART 3 - EXECUTION

3.1 GENERAL

A. The MCCs shall be erected in accordance with the recommendations of the manufacturer and with the details specified herein.

B. Cables larger than No. 6 AWG, which hang from their vertical connections, shall be supported within 2 feet of the connection.

C. The motor overload relays shall be provided and sized based on the actual full load amperes of the motor connected to the starter.

D. The motor circuit protectors shall be adjusted to the lowest settings that do not cause false tripping.

E. Motor control centers shall be installed for seismic requirements as required in division 260000 “General Electrical Requirements”.

F. Motor Control Centers shall be provided in accordance with all applicable sections of division 260000.

3.2 FIELD TESTS

A. MCCs shall be tested in accordance with Section 260000.

END OF SECTION 262419

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Weather-resistant receptacles.
3. Snap switches and wall-box dimmers.
4. Solid-state fan speed controls.
5. Wall-switch and exterior occupancy sensors.
6. Communications outlets.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Appleton Electric Co. (Appleton).
2. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
3. Cooper Crouse-Hinds (Crouse-Hinds).
4. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
5. Killark.
6. Leviton Mfg. Company Inc. (Leviton).
7. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES FOR UNCLASSIFIED AREAS

A. General Description

1. Convenience Receptacles, 125 V, 20 A
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
3. Straight blade, grounding type, specification grade.
4. Color: White unless Owner or Engineer specifies otherwise. Ivory for weather resistant receptacles. Yellow for corrosion resistant receptacles.
5. Provide weather resistant receptacles for damp and wet areas (including all process areas or areas that may be sprayed down).
6. Provide corrosion resistant receptacles for corrosive areas.

B. Products: Subject to compliance with requirements, provide the following:

1. Dry, non-corrosive locations:
    a. Hubbell; HBL5361 (single), HBL5362 (duplex).
    b. Or Approved Equal.
2. Damp or wet locations:
    a. Hubbell; HBL5361WR (single), HBL5362WR (duplex).
    b. Or Approved Equal.
3. Corrosive locations:
    a. Hubbell; HBL53CM61 (single), HBL53CM62 (duplex).
    b. Or Approved Equal.

2.4 RECEPTACLES FOR CLASSIFIED AREAS

A. General Description

1. Explosion proof, UL Listed for Class 1 Division I and II Groups C & D
2. Rated for 125 V, 20 A
3. Corrosion Resistant with malleable iron mounting box.
4. "Dead-front" construction requiring plug to be inserted and rotated to activate receptacle.
5. Factory Sealed so that seal-offs are not required at the receptacle.
6. If receptacles are to have GFCI, this shall be achieved at the branch circuit overcurrent protective device (typically a lighting panel) in an unclassified space.

B. Products: Subject to compliance with requirements, provide the following:

1. Appleton U-Line Contender series.
2. Crouse-Hinds Arktite Series.
3. Or Approved Equal.

2.5 GFCI RECEPTACLES FOR UNCLASSIFIED AREAS

A. General Description:

1. Duplex GFCI Convenience Receptacles, 125 V, 20 A.
2. Straight blade, feed-through type.
3. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
4. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
5. Receptacles shall be tamper and weather resistant.

B. Products: Subject to compliance with requirements, provide the following:

1. Hubbell; GFR5362TR.
2. Or Approved Equal.

2.6 TOGGLE SWITCHES FOR UNCLASSIFIED AREAS

A. General Description:

1. Toggle Switches, 120/277 V, 20A
2. Comply with NEMA WD 1, UL 20, and FS W-S-896.
3. Toggle type, quiet action, specification grade with grounding terminal.
4. Back and side wired, silver alloy contacts.
5. Color: White unless Owner or Engineer specifies otherwise.
6. For corrosive or wet areas, provide a NEMA 4X watertight, dust-tight and corrosion resistant cover.

B. Switches:

1. Products: Subject to compliance with requirements, provide the following:

a. Switches, 120/277 V, 20 A:
   1) Hubbell; HBL1221 (Single Pole); HBL1222 (Double Pole); HBL1223 (Three Way); HBL1224 (Four Way).
   2) Or Approved Equal.

b. Illuminated Switches (illuminated when switch is “off”:
   1) Hubbell; HBL1221IL (Single Pole); HBL1223IL (Three Way).
   2) Or Approved Equal.

c. Key-Operated Switches (with factory supplied key):
   1) Hubbell; HBL1221L
   2) Or Approved Equal.

2.7 TOGGLE SWITCHES FOR CLASSIFIED AREAS

A. General Description:

1. Explosion proof, UL Listed for Class 1 Division I and II Groups C & D
2. Rated for 125 V, 20 A
3. Corrosion Resistant with malleable iron body and cover.
4. Factory Sealed so that seal-offs are not required at the receptacle.
5. Front operated handle with stainless steel shaft.
6. With grounding screw.

B. Products: Subject to compliance with requirements, provide the following:

1. Appleton Contender series.
2. Crouse-Hinds EDS Series.
3. Or Approved Equal.

2.8 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "off." Load shall not exceed 80% of dimmer rating.

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish except for stainless steel wall plates whose screws shall be stainless steel.
2. Material for Finished Office Spaces: Smooth, high-impact thermoplastic, color to match device color.
3. Material for Finished Spaces: Type 304 stainless steel.
4. Material for Unfinished Spaces: Type 304 stainless steel.
5. Material for Damp and corrosive Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant**,** die-cast aluminum with lockable cover.

C. Weatherproof, While-In-Use Covers: Where receptacles are required to be weatherproof and physically protected while in use or idle or where shown on the drawings, weatherproof, while-in-use covers shall be used in lieu of other covers. The cover shall have the following features:

1. General Description:

a. Suitable style receptacle plate with a hinged cover.
b. Cord port(s) capable of allowing an appropriate size electrical cord(s) to pass through when the cover is closed.
c. Latching mechanism to allow the enclosure to maintain weatherproof integrity. The latch shall be a tamper resistant (locking/security) style in areas where security is needed.

d. Sufficiently deep to allow full closure with plug(s) in use.
e. UL listed per UL Standard 514C and conform to NEC Article 410.57 paragraphs a and b, Article 110.3 and Article 110.11.
f. Body materials shall be of a flame resistant, self-extinguishing, UV inhibiting, impact resistant, polycarbonate resin. Materials must meet UL Standard 94 HF1.
g. Mounting screws shall be stainless steel and of sufficient length to properly secure the device and ensure seal to mounting surface.

2. Products: Subject to compliance with requirements, provide the following:

a. Cooper; TP74 Series.
b. Or Approved Equal.

2.10 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: White unless Owner or Engineer specifies otherwise or otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to UPS or Emergency Power System: Red.
3. TVSS Devices: Blue.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Wherever possible, wiring devices shall be recess mounted with switches, receptacles and wall plates flush with the wall or surface.
2. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
3. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
4. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
5. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
6. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
7. Use a torque screwdriver when a torque is recommended or required by manufacturer.
8. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
9. Tighten unused terminal screws on the device.
10. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.
2. Where more than one receptacle is installed in a room, they shall be symmetrically arranged.
3. Set switches and receptacles plumb and vertical to the floor.
4. Set recess-mounted switches and receptacles flush with face of walls.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening. Provide blank plates for empty boxes.

G. Dimmers:

1. Install dimmers within terms of their listing.

2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
4. Do not connect dimmers to loads in excess of 80% of the rating of the dimmer.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262819 – DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section covers electrical disconnecting switches.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 26000, and elsewhere in the Contract Documents, prior to installation.

PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES

A. Disconnect switches shall be heavy-duty safety switches with a quick-make, quick-break operating mechanism, with full cover interlock, and indicator handle.

B. Where specified as fused disconnect switches, disconnects shall be furnished with fuses of the size indicated on the Plans. One set of spare fuses shall be furnished for each fused disconnect switch.

C. Disconnect switches shall be NEMA type HD heavy duty construction, UL 98 listed.

D. Enclosures shall be rated NEMA 12 for indoor use, and NEMA 3R for outdoor use, unless otherwise indicated on the Plans.

E. Disconnect switch handle shall be padlockable.

F. Disconnect switches in damp, wet or corrosive areas as indicated on the Plans, shall be NEMA 4X, 304 stainless steel. All disconnect switches in wastewater applications shall be NEMA 4X unless otherwise noted on the plans.

G. Disconnect switches located in hazardous locations shall be rated NEMA 7.

G. Disconnect switches shall be as manufactured by Square D, Cutler-Hammer, Allen-Bradley, no equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Disconnect switches shall be installed as indicated on the Plans.

B. Provide grounding per NEC, and Section 260526.

END OF SECTION 262819

SECTION 262923 - VARIABLE-FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, pre-assembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. See Section 26 24 19 "Motor-Control Centers" for VFDs installed in motor-control centers.

1.2 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).
B. CPT: Control power transformer.
C. EMI: Electromagnetic interference.
D. IGBT: Insulated-gate bipolar transistor.
E. LAN: Local area network.
F. LED: Light-emitting diode.
G. MCP: Motor-circuit protector.
H. NC: Normally closed.
I. NO: Normally open.
J. OCPD: Overcurrent protective device.
K. PCC: Point of Common Coupling
L. PID: Control action, proportional plus integral plus derivative.
M. PWM: Pulse-width modulated.
N. P&ID: Process & Instrumentation Diagram
O. RFI: Radio-frequency interference.
P. SCADA: Supervisory control and data acquisition.
Q. TDD: Total Demand Distortion
R. THD: Total Harmonic Distortion
S. VFD: Variable-frequency drive.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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 rating of VFD indicated.

B. System Harmonics Analysis: For each VFD and for the distribution system as a whole.

C. Shop Drawings: For each VFD indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings.
2. Schematic and Connection Wiring Diagrams: For power, signal, communications, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFDs. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Seismic Qualification Certificates: For VFDs, 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. Product certificates.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

B. 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.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test VFD according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

1.8 WARRANTY

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

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Rockwell Automation, Inc.; Allen-Bradley PowerFlex 700 series drives.
2. Schneider Electric, Inc.; Altivar Process 630 series drives.
3. Eaton SVX/SPX9000 series drives.

B. General Requirements for VFDs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. Application: Constant torque and variable torque.

D. VFD Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

F. Output Rating: Three-phase; 10 to 200 (60 as programmed default) Hz, programmable as voltage proportional to frequency throughout voltage range or with sensorless vector control; maximum voltage equals input voltage.

G. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFD input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: Equal to the rating of the gear feeding the drive. If not listed, 65 kA.
7. Ambient Temperature Rating: Not less than 14 deg F (minus 10 deg C) and not exceeding 122 deg F (50 deg C). This is specifically the requirement for the VFD unit itself and not the overall panel assembly. The overall assembly shall meet the requirements of 260000-1.4-A-8 which requires the overall assembly to operate at an ambient temperature of up to 104°F. Electrical equipment not rated for operation at that temperature shall be provided with air conditioning. The majority of the MCC's for the project are located indoors in air-conditioned rooms which satisfies this requirement. VFD assemblies shall have appropriately designed ventilation and or air conditioning so as to protect the internal components and to keep internal panel temperatures below the internal components' rated temperatures.
8. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F (70 deg C)
9. Humidity Rating: Less than 95 percent (noncondensing).
10. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
11. Vibration Withstand: Comply with IEC 60068-2-6.
12. Overload Capability: VFD system shall be rated for continuous operation at a minimum of 110% of motor load full load amps (FLA) times the motor service factor. Variable torque inverters shall be capable of delivering 110% of continuous rating for a minimum of 60 seconds. Constant torque inverters shall be capable of delivering 150% of continuous rating for a minimum of 60 seconds.
13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
14. Speed Regulation: Plus or minus 0.6 Hz.
15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
16. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

H. Inverter Logic: Microprocessor based, VFD isolated from all power circuits.

I. Isolated Control Interface: Allows VFDs to follow remote-control electrical signal over a minimum 100:1 speed range.

J. 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: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

K. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFD and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor overtemperature fault.

L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

M. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

N. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

O. 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.

P. 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.

Q. Integral Input Disconnecting Means and OCPD: NEMA AB 1, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFD input current rating.

2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.

2.2 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. VFD Fault.
4. All other lights as shown on the design drawings

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

C. Historical Logging Information and Displays:

1. Running log of total power versus time.
2. Total run time.
3. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFD door and connected to display VFD parameters including, but not limited to:

1. Output frequency (Hz).
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. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. Speed Reference: The VFD drive shall be capable of being controlled locally by a speed potentiometer or remotely by a 4- to 20-mA dc signal. The 4- to 20-mA signal shall be galvanically isolated and input resistance shall not exceed 250 ohms.

b. A minimum of two programmable analog inputs shall be provided and would be typically used for PID process variable and set point. These signals shall be setup to accept a 4- to 20-mA dc signal. The 4- to 20-mA signal shall be galvanically isolated and input resistance shall not exceed 250 ohms.

c. A minimum of six multifunction programmable digital inputs. The drive shall be expandable to handle additional digital inputs if required. The digital inputs shall be programmable to perform functions including, but not limited to:

1) VFD Start/Stop Control (2 or 3 wire)
2) Forward/Reverse/Stop Control
3) Local/Remote. The VFD shall be programmable so that "Local" control may either be the keypad or by hard-wired start/stop and potentiometer. The VFD shall be programmable so that "Remote" control may either be hard-wired start/stop and 4- to 20mA speed control or via the communications network.
4) VFD Interlock/Enable. This input when de-energized will not allow the VFD to run the motor under any circumstance.
5) VFD External Fault. This input will trip the VFD and require a reset before allow the motor to run again.
6) Preset Frequencies. The VFD shall be programmable to run at pre-programmed frequencies with up to 6 different steps.

2. Output Signal Interface:

a. A minimum of two programmable analog output signals 4- to 20-mA dc, which can be configured for any of the following:

1) Output frequency (Hz).
2) Output current (load).
3) DC-link voltage (V dc).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set point frequency (Hz).
7) Motor power (kW)

b. A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following (the drive shall be expandable to handle additional digital outputs if required):

1) Motor running.
2) VFD ready.
3) Set point speed reached.
4) Fault and warning indication (overtemperature or overcurrent).
5) PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: One.

G. SCADA Interface: Factory-installed hardware and software to enable the SCADA to monitor, control, and display VFD status and alarms and energy usage. Allows VFD to be used with an

external system within a multidrop LAN configuration; settings retained within VFD's nonvolatile memory.

1. Network Communications Ports: Ethernet
2. SCADA Protocols for Network Communications: Ethernet/IP protocol accessible via the communications ports.

2.3 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: All new power distribution systems supplied shall be required to meet the requirements of IEEE 519-1992. Specifically, the system shall adhere to the TDD requirements of Table 10-3 of IEEE 519-1992. If the power distribution system is equipped with an Active Harmonic System, each VFD shall be equipped with a line reactor whose impedance is as recommended by the Active Harmonic System manufacturer (typically 3%). If no Active Harmonic System is part of the power distribution system, the following rules as a minimum shall define the input line conditioning for each VFD (unless further conditioning is required to meet the IEEE 519-1992 limits). With the Engineer's approval, the contractor may decide to supply an Active Harmonic System even if not shown on the drawings, with corresponding reactors and chokes (this would typically occur if it is more cost effective to meet IEEE 519 with a single system then multiple harmonic filters).

1. All VFD's sized for motors 50HP or larger shall be equipped with DC-link chokes.
2. All VFD's sized for motors 40HP and less shall be equipped with 5% line reactors unless specifically called out as otherwise on the drawings.
3. All VFD's sized for 50HP to 200HP motors shall be equipped with passive harmonic filters with DC Link Chokes.
4. All VFD's greater than 200HP shall have be setup to have less than 5% THD for both voltage and current. This would typically require that the drive is setup with an 18-pulse front end or with an active harmonic filter. The VFD assembly shall accept a single 3-phase input and shall contain all of the harmonic mitigation equipment as part of the assembly.

B. EMI/RFI Filtering: VFD's shall be CE marked and certify compliance with IEC 61800-3 for Category C2.

2.4 LOAD CONDITIONING

A. Load Conditioning: For VFD driven loads with conductor lengths between 200 and 1,000 feet, output dV/dt filters shall be provided as part of the VFD assembly. It is strongly recommended that VFD motor leads not be longer than 500 feet and alternative VFD locations should be considered. If absolutely necessary, loads with conductor lengths greater than 1,000 feet shall have output sine wave filters shall be provided as part of the VFD assembly. Voltage drop considerations shall be taken into account when selecting the motor's nameplate voltage.

2.5 LINE AND LOAD CONDITIONING EQUIPMENT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. MTE Corporation.
2. Transcoil International (TCI).
3. Or approved equal.

B. Line Reactors: Reactors shall be part of the VFD assembly. They shall be sized based upon the VFD input power requirements. They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The reactor shall meet the following criteria:

1. The reactor shall be UL 508 listed.
2. Continuous current rating: 100% RMS.
3. Intermittent current ratings: 150% for 60 seconds; 200% for 10 seconds.
4. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
5. All wiring shall be copper.

C. Passive Harmonic Filters: Filters shall be part of the VFD assembly. They shall be sized based upon the VFD input power requirements. They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. The filter shall filter harmonics generated by the nonlinear VFD to satisfy the requirements of IEEE 519-1992 for individual and total harmonic voltage and current distortion at the input terminals of the filter.
3. The TDD of the current at the input terminals of the filter shall not exceed the limits defined in Table 10-3 of IEEE 519-1992.
4. Full load efficiency: 97% or greater
5. The filter shall not resonate with the power distribution system nor attract harmonics from other sources.
6. The harmonic filter shall be a passive series connected low pass filter consisting of an inductor capacitor network. Active electronic components shall not be used.
7. The harmonic filter shall be equipped with a contactor that will connect the capacitor(s) only when the motor is running, avoiding nuisance VFD over-voltage tripping.
8. All wiring shall be copper.

D. dV/dt Filters: Filters shall be part of the VFD assembly. They shall be sized based upon motor horsepower and required full-load current (including service factor). They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. Maximum peak motor terminal voltage with 500 feet of cable: 15% of bus voltage.
3. Maximum dV/dt: 200 Volts per microsecond.

4. The dV/dt Filter shall reduce common mode voltages by a minimum of 40%.
5. Continuous current rating: 100% RMS.
6. Intermittent current ratings: 150% for 60 seconds; 200% for 10 seconds.
7. Allowed inverter switching frequencies: 1kHz to 8 kHz.
8. Nominal inverter operating frequency: 60Hz; Minimum – 6 Hz; Maximum with de-rating: 120Hz.
9. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
10. Insertion loss: 3% of rated voltage maximum.
11. All wiring shall be copper.

E. Sine Wave Filters: Filters shall be part of the VFD assembly. They shall be sized based upon motor horsepower and required full-load current (including service factor). They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. Harmonic Voltage Distortion: 10% maximum
3. Continuous current rating: 100% RMS.
4. Intermittent current rating: 150% for 60 seconds.
5. Allowed inverter switching frequencies: 2kHz to 8 kHz.
6. Nominal inverter operating frequency: 60Hz; Minimum – 0 Hz; Maximum with de-rating: 90Hz.
7. The Sine Wave Filter shall reduce common mode voltages by a minimum of 40%.
8. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
9. Insertion loss: 6% of rated voltage maximum.
10. All wiring shall be copper.

2.6 BYPASS SYSTEMS

A. Provide Bypass Systems only if indicated on the drawings.

B. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

C. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.

D. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: Load-break, NEMA-rated contactor.

2. Output Isolating Contactor: Non-load-break, NEMA-rated contactor.
3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

E. Bypass Contactor Configuration: Full-voltage (across-the-line) or reduced voltage soft-starter as shown on the drawings.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFD while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 100 VA.

6. Overload Relays: NEMA ICS 2.

2.7 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry, Clean and Non-corrosive Indoor Locations: Type 1.
2. Outdoor or Corrosive Locations: Type 4X, stainless steel.
3. Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.8 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFD enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

    a. Push Buttons: Maintained and/or momentary as required.
    b. Pilot Lights: LED types; colors as shown on P&ID's; push to test.
    c. Selector Switches: Rotary type.

B. Bypass contactor auxiliary contact(s) as required.

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Analog Meters:

1. Elapsed time meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4, 4X, and 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4, 4X, 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Cooling Fan and Exhaust System: For NEMA 250, maintaining enclosure NEMA rating; UL 508 component recognized: Supply fan, with non-corrosive intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

I. Air Conditioning System: For NEMA 250, maintaining enclosure NEMA rating; UL 508 component recognized; sized to maintain internal temperatures at or below 100°F.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.

1. Test each VFD while connected to its specified motor.
2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounting Controllers: Install VFDs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Seismic Bracing: Comply with requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFD.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFD with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
9. Perform voltage and current harmonic test with each VFD running at minimum and maximum speed. Submit test results for each VFD. Testing shall be witnessed by the Owner and the Engineer.

E. VFDs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs. A minimum of 4 hours of training shall be provided. The training shall cover VFD theory of operation, features and functions available, normal operation, troubleshooting, and routine maintenance. The Contractor shall submit a syllabus for the training session for approval, within 3 weeks of conducting the class. Provide each attendee with a class syllabus detailing each topic to be discussed.

3.7 SPARE PARTS

A. The following spare parts shall be supplied with each type, or frame size, of VFD:
   1. 3 sets of all replaceable fuses
   2. 3 spare air conditioner or fan filters

END OF SECTION 262923

SECTION 265000 – LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.

1.2 SCOPE OF WORK

A. The Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install lighting fixtures.

1.3 QUALITY ASSURANCE

A. Reference Standards:

1. National Electrical Code (NEC)
2. UL Standard #57, Electric Lighting Fixtures
3. UL Standard #844, Electric Lighting Fixtures for Use in Hazardous Location
4. UL Standard #1570, Fluorescent Lighting Fixtures
5. UL Standard #1571, Incandescent Lighting Fixtures
6. UL Standard #1572, High Intensity Discharge Lighting Fixtures
7. Illuminating Engineering Society (IES)
8. All applicable local lighting ordinances

B. Miscellaneous:

1. Lamps are identified for each luminaire in the Lighting Fixture Schedule on the Plans.
2. Lighting fixtures and electrical components:
    a. UL labeled, complete with lamps.
    b. Rated for area classification as indicated.
        1) All lighting in classified areas are to be of the T3 temperature class unless otherwise indicated, refer to Table 500.8(B) of the NEC.
    c. Lighting shall meet OSHA requirements.
3. On the Plans, the location of lighting fixtures is intended to be used as a guide.
    a. Field conditions may affect actual locations.
    b. Coordinate with other trades to avoid conflicts in mounting of fixtures and other equipment.
4. The quality standard is established by the fixture listed in the Lighting Fixture Schedule.

a. This quality standard includes, but is not necessarily limited to construction features, materials of construction, finish, and photometrics.

1.4 SUBMITTALS

A. The following shall be submitted to the Engineer for review:

1. Acknowledgment that products submitted meet requirements of standards referenced.
2. Manufacturer's technical information on products to be used including photometric performance curves for the fixture and ballast data.
3. Acknowledgment that products submitted are UL listed.
4. When general data sheets constitute part of the submittal, identify the products to be used on this project.
5. Manufacturer's installation instructions.
6. Identification of fixtures by Lighting Fixture Schedule.
7. UL nameplate data (Voltage, wattage, etc.).
8. Finishes, colors, and mounting type.
9. Pole, fixture, and accessories.
10. Pole wind loading.

B. Contractor shall submit shop drawings, manufacturer's data sheets, and a complete wiring diagram detailing all connections to the electrical system in accordance with Section 013300 "Contractor Submittals" and Section 260000 "General Electrical Requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Lamps shall be manufactured by:

1. General Electric
2. North American/Phillips
3. Sylvania
4. Approved equal.

B. Lighting fixtures shall be provided as indicated on the Lighting Fixture Schedule on the Plans.

C. Lighting ballasts shall be manufactured by:

1. General Electric
2. Advance
3. Jefferson
4. Universal
5. Bodine
6. Lithonia
7. Approved equal

D. Light poles shall be as indicated on the Plans. Include base template, anchor bolts, cadmium-plated hardware and pole grounding lug, hand-hole, anchor base and bolt covers. Pole foundations shall be as indicated on the Plans.

2.2 MATERIALS

A. General:

1. Lamps:
   a. See lighting fixture schedule on Plans for wattage, voltage and number required.
2. All Fixtures:
   a. There shall be no live parts normally exposed to contact.
   b. When intended for use in wet area:
      1) Mark fixtures “suitable for wet locations.”
   c. When intended for use in damp areas:
      1) Mark fixtures “suitable for damp locations” or “suitable for wet locations.”
   d. In wet or damp area, install fixtures so that water cannot enter or accumulate in the wiring compartment, lamp-holder, or other electrical parts.
   e. Gasket seals: Urethane foam
   f. Diffusers: UV stabilized acrylic plastic
3. Underground wiring:
   a. Provide all wiring runs with separate green grounding conductor.
   b. Ground all pole bases.
4. Pole wiring from base to ballast:
   a. No. 12 type XHHW.
   b. Each phase shall be protected by a 30A, 600V, type Tron waterproof fuse-holder, Bussman “Limitron” type fuse, size rating 3-times load current.

B. Incandescent Lamps:

1. No incandescent lamps shall be allowed.

C. Fluorescent Lamps:

1. Rapid start
2. Cool white (F32T8/41K-85CRI and F96T12/41K-70CRI/HO/ES)
3. Energy efficient or standard as noted on the lighting fixture schedule.

D. High-Pressure Sodium Lamps:

1. No High-Pressure Sodium Lamps shall be allowed.

E. Metal Halide Lamps:

1. No Metal Halide Lamps shall be allowed.

F. LED:

1. Lifespan: 50,000 hour
2. Minimum CRI: 70 outdoors, 80 indoors
3. Color Temperature: 3500K outdoors, 4000K indoors

G. Furnish a minimum of 2 lamps, or ten percent spare lamps of each type and wattage, whichever is greater.

2.3 FIXTURES

A. Fluorescent Lighting Fixtures:

1. Ballast:
   a. Rapid start, high power factor type
   b. CBM/ETL certified
   c. Sound rating A
   d. Two internal automatic-resetting thermal switch devices for coil and capacitor
2. Internal wiring: AWM, TFN or THHN
3. Channel and end plates: 22 GA steel
4. Steel door frame and socket track: 20 GA steel
5. Channel cover: 24 GA steel
6. Emergency ballast:
   a. Integral rechargeable nickel-cadmium battery, battery charger, and automatic transfer circuitry.
   b. Charging indicator light.
   c. Test Switch.
   d. Provide a minimum of 900 lumen output for 90 minutes upon loss of normal power.
   e. Mounted integral to the fixture.
   f. UL 924 listed.
7. Provide fixtures with emergency ballasts with permanent caution labels warning that the fixture is fed from an un-switched source
   a. Provide emergency ballast also with a similar caution label.

B. LED Lighting Fixtures:

1. Heavy duty two piece, die cast aluminum housing.
2. Silicon gasketing for moisture protection
3. Polyester powder finish for impact, corrosion and UV resistance
4. Cast-in aluminum hinges for tool-less lens removal.
5. Thermal and shock resistant clear borosilicate glass refractor.
6. Field replaceable LED light engine and driver.

2.4 EMERGENCY FLUORESCENT POWER UNIT

1. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.

a. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.

2. Nightlight Connection: Operate one fluorescent lamp continuously.
3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
   a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.5 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: Fluorescent, two for each fixture, 20,000 hours of rated lamp life.
2. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
3. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
   a. Battery: Sealed, maintenance-free, nickel-cadmium type.
   b. Charger: Fully automatic, solid-state type with sealed transfer relay.
   c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.6 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.

3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.

2.7 MISCELLANEOUS ELECTRIC DEVICES

A. PHOTOELECTRIC CONTROL UNITS shall meet the following requirements:

1. Cadmium sulfide photocell
2. Aluminum weatherproof enclosure
3. 30 amp rated contacts
4. 120-volt AC power
5. The Photoelectric control unit shall be Tork Model 2100, or equal.

B. MOTION SENSORS shall meet the following requirements:

1. 110° field of view, 60-foot range
2. Adjustable time setting from 15 seconds to 15 minutes
3. Operating temperature of -20 to + 130 °F.
4. Complete outdoor, weatherproof sensor with complete mounting hardware
5. UL listed
6. The motion sensor(s) shall be manufactured by Leviton Model 50500-H or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Comply with NFPA 70 for minimum fixture supports.

C. Install lamps in all luminaires.

D. Replace all failed fluorescent, incandescent, metal halide, mercury vapor, high pressure sodium and LED lamps with new lamps prior to final acceptance by Owner.

E. Surface and flush mounted fixtures shall be solidly connected to a junction box. Suspended fixtures shall be hung utilizing pendant mounting or stainless-steel chains and hooks. Each suspended fixture shall be electrically connected by a length of Type SO flexible cord. 3 conductor No. 14 AWG, minimum, with a twist-lock receptacle mounted in an individual junction box. Plugs and receptacles shall be as manufactured by Hubbell, General Electric Company, or equal.

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

G. Install with approved mounting hardware following manufacturer's recommendations.

H. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports, and nonmetallic channel and angle supports.

1. Do not support fixture from conduit system.
2. Do not support fixture from outlet boxes.

I. Pole mounted fixtures shall be mounted on steel or aluminum poles as indicated on the Plans. All metal poles shall be bonded to the facility ground system. Poles shall have adequate handholes and weatherproof receptacles where indicated.

J. All anchor bolts and nuts shall be stainless steel. Contractor shall paint all steel poles with aluminum paint or other color in accordance with these Contract Documents.

K. Fixture mounting heights and locations indicated on the Plans are approximate and are subject to revision in the field where necessary to avoid conflicts and obstructions.

3.2 ADJUSTING AND CLEANING

A. Wipe all lighting fixture reflectors, lenses, lamps, and trims clean after installation and prior to acceptance of Project by Owner.

3.3 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

END OF SECTION 265000

SECTION 31 05 16
AGGREGATE MATERIALS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Coarse aggregate materials.
2. Fine aggregate materials.

B. Related Sections:

1. Section 31 11 20 – Soil Materials: Fill and grading materials.
2. American Public Works Association (APWA) Specifications (latest version).
3. Santaquin City Standards.

1.2 REFERENCES

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

1. AASHTO M147 - Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.

B. ASTM International (ASTM):

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D1557 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 foot-pounds/foot^3 (2,700 kN-m/m^3))
3. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
4. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.3 SUBMITTALS

A. Section 01 33 00 – Submittal Procedures: Requirements for submittals.

B. Materials Source: Submit name of imported materials suppliers with proctor and gradation test data for each imported material.

C. Samples: Submit, in air-tight containers, 45-pound sample of each type of aggregate material used for fill to testing laboratory.

1.4 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

PART 2 PRODUCTS

2.1 COARSE AGGREGATE MATERIAL TYPES

A. Type M1, Structural Fill:
Natural or crushed sandy gravel; free of clay, shale, organic matter. The portion of the material finer than a No. 40 sieve shall have a plasticity index less than six. Structural fill shall be densified to an in-place unit weight equal to at least 95 percent of the maximum laboratory density as determined by ASTM D1557.

Sieve Size	Percent Passing
3-inch	100
¾-inch	70
No. 200	5-20

Use for structural fill beneath foundations and shallow footings and as shown on the Drawings.

B. Type M2, Granular Backfill:
Imported granular backfill is required to establish final grade throughout the site. The portion of the material passing a No. 40 sieve shall have a plasticity index less than six. The fill shall be compacted to an in-place density equal to at least 92 percent of the maximum density as determined by ASTM D1557.

Sieve Size	Percent Passing
6-inch	100
No. 200	0 to 30

Use for imported granular backfill and as shown on the Drawings.

C. Type M3, Free Draining Floor Slab Base Course: Nonplastic, clean crushed angular rock:
A 6-inch thick free-draining gravel layer shall be placed immediately beneath floor slabs, and this material shall be underlain by a 6-inch layer of compacted structural fill. The free-draining material shall be densified using at least four passes of a smooth drum 5-ton vibratory roller or equivalent.

Sieve Size	Percent Passing
1-inch	100
No. 200	0 to 5

Use for free draining gravel under concrete floor slabs.

D. Type M4, Stabilization Cobble Rock: Angular to subangular cobble rock:

Size	Percent Passing
8-inch	100
3-inch	30
No. 200	0 to 5

Press cobble rock into the subgrade in 12-inch thick lifts where authorized by the Engineer to stabilize soft and unstable subgrade. Avoid otherwise disturbing the subgrade.

If the subgrade remains unstable after pressing in two 12-inch thick lifts, leave subgrade undisturbed for at least 24 hours and then review conditions with the Engineer.

Remove any excess rock that cannot be pressed into the subgrade to ensure nesting does not occur and voids are not left between cobbles.

2.2 UNTREATED BASE COURSE

A. Type M5, Aggregate Base Course (Road Base): Free of shale, clay, friable material and debris; Meet Utah Department of Transportation (UDOT) Aggregate Base Couse, Standard Specification Section 02721:

Sieve Size	Percent Passing
1-½-inch	100
1-inch	90 to 100
¾-inch	70 to 85
½-inch	65 to 80
3/8-inch	55 to 75
No. 4	40 to 65
No. 16	25 to 40
No. 200	7 to 11

2.3 PIPE TRENCH BACKFILL MATERIALS

A. Type P1, Foundation Material:

Sieve Size	Percent Passing
2-inch	100
½-inch	0 to 5

B. Type P2, Bedding and Initial Backfill Material (Ductile Iron Pipe):

Sieve Size	Percent Passing
2-inch	100
No. 200	0 to 5

C. Type P3, Bedding and Initial Backfill Material (PVC or Polyethylene Pipe):

Sieve Size	Percent Passing
2-inch	100
No. 200	0 to 5

D. Type P4, Final Backfill Material:

Sieve Size	Percent Passing
3-inch	100
No. 200	0 to 15

2.4 SOURCE QUALITY CONTROL

A. Coarse Aggregate Material - Testing and Analysis: Perform in accordance with, ASTM D1557, ASTM D4318, ASTM C136.

B. Fine Aggregate Material - Testing and Analysis: Perform in accordance with, ASTM D1557, ASTM D4318, ASTM C136.

C. When tests indicate materials do not meet specified requirements, change material, moisture condition or dry as necessary and retest.

PART 3 EXECUTION

3.1 STOCKPILING

A. Stockpile materials on site at locations designated by Engineer.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Separate different aggregate materials with dividers or stockpile individually to prevent mixing.

D. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.2 STOCKPILE CLEANUP

A. Remove unused stockpile materials.

B. When borrow area is indicated, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 31 05 19
GEOTEXTILES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Geotextiles

1.2 RELATED SECTIONS

A. American Public Works Association (APWA) Specifications (latest version)

B. Santaquin City Standards

1.3 REFERENCES

A. ASTM D 5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

B. ASTM D 4355, Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

C. ASTM D 4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

D. ASTM D 4533, Standard Test Method for Index Trapezoidal Tearing Strength of Geotextiles.

E. ASTM D 4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

F. ASTM D 4873, Guide for Identification, Storage and Handling of Geotextiles.

G. ASTM D 4491, Standard Test Method for Water Permeability of Geotextiles by Permittivity.

H. ASTM D 4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.

I. ASTM D 4354, Standard Practice for Sampling of Geosynthetics for Testing.

J. ASTM D 4759, Standard Practice for Determining the Specifications Conformance of Geosynthetics.

K. AASHTO M288-00, Geotextile Specification for Highway Applications.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00. Document compliance with these Specifications. Indicate products are suitable for application.

B. Product Data: Provide product physical and chemical properties. Prior to shipment, provide manufacturer's certification and quality control data to demonstrate the product meets or exceeds the specified requirements. Submit details and methods for anchoring the geotextile, making of field joints, joints in sumps, and liner penetrations

C. Manufacturer's instructions for storage, handling, installation and joining.

D. Material warranties.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 01 70 00.

B. Record actual locations of field seams, samples, repairs and tests.

1.7 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

A. Deliver, label, store, protect and handle geotextile at site in accordance with manufacturer's guidelines and ASTM D 4873.

PART 2 PRODUCTS

2.1 GEOTEXTILE

A. Geotextiles shall be non-woven needle punched as specified herein.

B. Geotextile shall be manufactured from prime quality virgin polymer.

C. New, first quality product designed and manufactured specifically for the purpose of this work with the following properties:

Tested Property	Test Method	Frequency	Minimum Average Value
AASHTO M288 Class			>>1
Mass per Unit Area, oz/yd2	ASTM D 5261	90,000 ft^2	12
Grab Tensile Strength, lb	ASTM D 4632	90,000 ft^2	300
Grab Elongation, %	ASTM D 4632	90,000 ft^2	50
Puncture Strength, lb	ASTM D 4833	90,000 ft^2	140
Trapezoidal Tear Strength, lb (N)	ASTM D 4533	90,000 ft^2	115
Apparent Opening Size, Sieve No. (mm)	ASTM D 4751	540,000 ft^2	100
Permittivity, sec~'	ASTM D 4491	540,000 ft^2	0.80
Water Flow Rate, gpm/ft^2 (l/min/m^2)	ASTM D 4491	540,000 ft^2	60
UV Resistance (% retained after 500 hours)	ASTM D 4355	Per formulation	70
Roll Length[1], ft (m)			300
Roll Width[1], ft (m)			15
Roll Area, ft^2 (m^2)			4,500

NOTES:

- The property values listed are in the weaker principal direction. All values listed are minimum average roll values except UV resistance; it is a minimum value.
- [1]Roll widths and lengths have a tolerance of ±1%.

D. Manufacture geotextile in accordance with the Manufacturer's Quality Control Plan.

E. Prior to shipment, the geotextile shall be tested according to the test methods and frequencies included in this specification. Test results shall be accepted by the Engineer prior to delivery to the project site.

F. For storm drain infiltration system/sump manholes, utilize Mirafi 600X geotextile fabric or approved equivalent.

PART 3 EXECUTION

3.1 PREPARATION

A. Verify that surfaces upon which the geotextile is to be placed are graded smooth, free of all sharp rocks or other sharp objects, vegetation and stubble and acceptable to receive geotextile.

B. Verify that all concrete surfaces upon which the geotextile is to be placed is steel trowel finished smooth with rounded corners.

C. Inspect stored geotextile to verify that it has not been damaged in storage or handling.

3.2 DEPLOYMENT

A. Handle the geotextile in such a manner to ensure it is not damaged in any way.

B. Observe condition of geotextile during deployment. Note any damaged areas and bring to the attention of the Engineer. Damaged geotextile may be rejected by the Engineer or may be accepted with repairs in accordance with these specifications depending on the proposed location and extent of damage to the geotextile. Coordinate areas to be repaired with Engineer if accepted.

C. Install geotextile to the lines and grades as shown in the Drawings.

D. During placement of geotextile, do not entrap soil, stones or excessive moisture.

E. Do not expose geotextile to precipitation prior to being installed.

3.3 SEAMS

A. Geotextile shall be seamed using heat seaming or stitching method.

B. For heat seaming, fusion welding techniques shall be as recommended by the manufacturer.

C. Sewn seams shall be made using polymeric thread with chemical resistance equal to or greater than the geotextile.

D. All sewn seams shall be continuous.

E. In areas of proposed repairs, the patch shall be secured to the original geotextile with seams as described herein.

F. If more than 33% of the width of a roll requires patching, the patch shall extend the full width of the roll.

3.4 COVERING GEOTEXTILES

A. Geotextile shall not be exposed to direct sunlight for more than 15 days after installation.

B. The Contractor shall not use heavy equipment or allow traffic on the geotextile without providing protection as recommended by the manufacturer. Follow manufacturer's recommendations for spreading soil and aggregate material in the sumps and over the geotextile separating the rock fill and soil fill.

C. Geotextile shall be covered as soon as practical after installation. Notify Engineer when installation is complete prior to covering the geotextile. Installed geotextile shall not be left exposed for more than 15 days.

D. Geomembrane liner shall be carefully placed over the geotextile to avoid wrinkling or damage to the geotextile.

E. Aggregate or soil placed over the geotextile shall be placed using methods that protect the geotextile. Tracked equipment shall not be used for this work. Utilize rubber wheeled equipment and minimize turning movements as material is “walked” onto the geotextile. Comply with manufacturer’s recommendations.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 31 10 00
SITE CLEARING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Surface debris removal.

B. Stripping construction site of plant life and grass including root systems to a minimum six inch depth.

C. Removal and disposal of shrubs, grasses, and trees.

D. Removing abandoned utilities.

1.2 RELATED SECTIONS

A. Section 01 50 00 – Temporary Facilities & Controls.

PART 2 PRODUCTS– NOT USED

PART 3 EXECUTION

3.1 PREPARATION

A. Request underground utilities to be located and marked within and surrounding construction areas.

B. Verify that existing plant life designated to remain is tagged or identified.

3.2 PROTECTION

A. Locate, identify, and protect utilities that remain from damage.

B. Protect trees, plant growth, and features designated to remain, as final landscaping or outside of construction limits.

C. Retain and protect bench marks, survey monuments, and existing structures and utilities from damage or displacement.

D. Protect roads, fences, and other items to remain during construction.

E. Protect all adjoining property.

F. Protect existing drainage ditches unless otherwise noted.

G. Prevent air pollution or dust from becoming a nuisance to the public, to neighbors, and to others performing work on or near the project site. Comply with governing regulations.

3.3 CLEARING

A. Clear areas required for access to site and execution of Work.

B. Remove trees, brush and shrubs within construction limits and in areas for which easements have been acquired. Remove stumps and roots completely.

C. Limit clearing and construction operation to areas required for construction and designated by the Engineer and within rights-of-way or easements obtained by the Owner.

3.4 REMOVAL

A. Remove debris and extracted plant life from site. Open burning and burial in trenches is prohibited.

B. Strip all heavy soils, heavy growths of grass, and sod that comprise the organic root-zone and dispose of offsite. The depth of stripping will generally be six (6) to twelve (12) inches.

C. Top soil stockpile shall be separated from other soil materials to prevent contamination.

D. Dispose all materials at locations that are in compliance with all Federal, State, and Local Regulations.

E. Grade areas in which groundwater is encountered to drain.

F. Remove abandoned utilities as required.

3.5 OBSTRUCTIONS

A. Remove and replace fences, fence post, signs and any structures encountered during construction to a condition equal to or better than it was prior to construction.

3.6 CLEANUP

A. Upon completion of the site work and project, clean the entire work area. Remove all excess excavated material, rocks, boulders, logs, trees, pipe, or debris of any type from the site and dispose at a site acceptable to Federal, State, and Local Regulations.

END OF SECTION

SECTION 31 11 20
SOIL MATERIALS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Subsoil materials
2. Topsoil materials

B. Related Sections:

1. Section 31 05 16 – Aggregate Materials
2. American Public Works Association (APWA) Specifications (latest version)
3. Santaquin City Standards

1.2 REFERENCES

A. ASTM International (ASTM):

1. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 foot-pound/foot^3 (2,700 kN-m/m^3)).
2. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
3. ASTM D2922 – Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth).
4. ASTM D3017 – Test Methods for Moisture Content of Soil and Soil Aggregate Mixtures in Place by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS

A. Section 01 33 00 – Submittal Procedures: Requirements for submittals.

B. Materials Source: Submit name of imported materials source. Provide materials from same source throughout the course of the project.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Furnish each material from single source throughout the Work.

PART 2 PRODUCTS

2.1 SUBSOIL MATERIALS

A. Subsoil Type S1: Excavated and reused material;

2.2 TOPSOIL MATERIALS

A. S3 (Topsoil): Select, graded, free of roots larger than ½ inch, subsoil, debris, large weeds and foreign matter.

1. Imported borrow.
2. Friable loam.
3. Reasonably free of roots, rocks larger than 1 inch, subsoil, debris, large weeds, and foreign matter.
4. Acidity range (pH) of 5.5 to 7.5
5. Containing minimum of 4 percent and maximum of 25 percent inorganic matter.

2.3 SOURCE QUALITY CONTROL

A. Testing and Analysis of Topsoil Material: Perform in accordance with ASTM D1557.

B. When tests indicate materials do not meet specified requirements, change material and retest.

C. Furnish materials of each type from same source throughout the Work.

PART 3 EXECUTION

3.1 EXCAVATION

A. Excavate topsoil from areas designated. Strip topsoil to full depth of topsoil in designated areas.

B. Stockpile excavated material meeting requirements for topsoil materials.

C. Remove excess excavated materials not intended for reuse, from site.

D. Remove excavated materials not meeting requirements for topsoil materials from site.

3.2 STOCKPILING

A. Stockpile materials on site.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Separate differing materials with dividers or stockpile apart to prevent mixing.

D. Stockpile topsoil 8 feet high maximum.

E. Prevent intermixing of soil types or contamination.

F. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.3 STOCKPILE CLEANUP

A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

3.4 NATURAL GROUND SURFACE RESTORATION

A. Unimproved areas not otherwise classified as Bituminous Surface, Gravel Surface, Gravel Shoulder or Sod Surface.

B. Restore disturbed surfaces along trench in accordance with surface repair details of the project plans.

C. Grade disturbed area to match previously existing terrain.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 31 22 13
ROUGH GRADING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating topsoil.
2. Excavating subsoil.
3. Cutting, grading, filling, rough contouring, and compacting for site structures.

B. Related Sections:

1. Section 31 05 16 – Aggregate Materials.
2. Section 31 10 00 – Site Clearing: Excavating topsoil.
3. Section 31 11 20 – Soil Materials.
4. Section 31 23 23 – Backfilling for Structures: General building area backfilling.
5. American Public Works Association (APWA) Specifications (latest version)
6. Santaquin City Standards

1.2 REFERENCES

A. ASTM International (ASTM):

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 foot-pounds/foot^3 (600 kN-m/m^3)).
3. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
4. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 foot-pounds/foot^3 (2,700 kN-m/m^3)).
5. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
6. ASTM D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
7. ASTM D2434 - Standard Test Method for Permeability of Granular Soils (Constant Head).
8. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

9. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS

A. Section 01 33 00 – Submittal Procedures: Requirements for submittals.

B. Materials Source: Submit name of imported materials suppliers. Provide materials from same source throughout the course of the project.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with ASTM C136, ASTM D2419, and ASTM D2434.

PART 2 PRODUCTS

2.1 MATERIALS

A. Topsoil: Type S3 as specified in Section 31 11 20.

B. Subsoil Fill: Type S1 as specified in Section 31 11 20.

C. Structural Fill: Type A1 as specified in Section 31 05 16.

D. Aggregate Base Course: Type A7 as specified in Section 31 05 16.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify survey bench mark and intended elevations for the Work are as indicated on Drawings.

3.2 PREPARATION

A. Call Local Utility Line Information service not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Identify required lines, levels, contours, and datum.

C. Notify utility company to remove and relocate utilities.

D. Protect utilities indicated to remain from damage.

E. Protect bench marks, survey control point, and existing structures from excavating equipment and vehicular traffic.

3.3 SUBSOIL EXCAVATION

A. Stockpile excavated material in area designated on site in accordance with Section 31 11 20.

B. Benching Slopes: Horizontally bench existing slopes greater than 1: 4 to key placed fill material to slope to provide firm bearing.

C. Stability: Replace damaged or displaced subsoil as specified for fill.

3.4 FILLING

A. Place material in continuous layers as follows:

1. Subsoil Fill: Maximum eight inches compacted depth.
2. Structural Fill: Maximum eight inches compacted depth.
3. Aggregate Base Course: Maximum six inches compacted depth.

B. Maintain optimum moisture content of fill materials to attain required compaction density.

C. Slope grade away from structure minimum two inches in 10 feet unless noted otherwise.

D. Make grade changes gradual. Blend slope into level areas.

E. Repair or replace items indicated to remain damaged by excavation or filling.

3.5 TOLERANCES

A. Section 01 40 00 – Quality Assurance and Quality Control: Tolerances.

B. Top Surface of Subgrade: Plus or minus 1/10 foot from required elevation.

3.6 FIELD QUALITY CONTROL

A. Section 01 40 00 – Quality Assurance and Quality Control: Testing and inspection services.

B. Perform laboratory material tests in accordance with ASTM D1557.

C. Perform in place compaction tests in accordance with the following:

1. Density Tests: ASTM D1556, ASTM D2167, or ASTM D2922.
2. Moisture Tests: ASTM D3017.

D. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

3.7 SCHEDULES

A. Structural Fill:

1. Compact uniformly to minimum 95 percent of maximum density.

B. Aggregate Base Course:

1. Compact uniformly to minimum 95 percent of maximum density.

END OF SECTION

SECTION 31 23 19
DEWATERING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Submittals

B. References

C. Permits

D. Preparation

E. Structure Dewatering

F. Verification

G. Dewatering Discharge

H. Termination

I. Measurement and Payment

1.2 RELATED SECTIONS

A. Section 01 10 00 – Summary of Work

B. Section 01 20 00 – Measurement and Payment

C. Section 01 40 00 – Quality Assurance and Quality Control

D. Section 01 52 00 – Temporary Facilities and Controls

E. American Public Works Association (APWA) Specifications (latest version)

F. Santaquin City Standards

1.3 SUBMITTALS

A. Prior to the preconstruction conference the Contractor shall submit their dewatering plan to the Engineer and Owner to communicate the Contractors intent in regards to dewatering to achieve the required performance contained in these specifications. Submittal of a dewatering plan shall not be interpreted as an acceptance or approval by the Owner or Engineer of the Contractor's dewatering plan. The dewatering plan shall include at a minimum:

1. Major components of the dewatering system including size, location, spacing and details of wells, well points, vacuum piping, sumps, interception trenches, pumps, and other major dewatering features the Contractor anticipates utilizing.
2. Details of scheduling of dewatering activities relative to excavation and structure installation including backfilling and ceasing dewatering activities.
3. Contingency plans for equipment or power failure.
4. Procedures for verification that water levels have been lowered to the specified levels prior to trench excavation and pipe installation.
5. Location of dewatering disposal or discharge locations and the capacity to accept dewatering discharge. Provide a contingency plan for higher than anticipated flows when capacity of planned discharge and disposal locations may conceivably be exceeded.
6. Location and details of Best Management Practices (BMP's)
7. Agreements with entities accepting discharges
8. All permits obtained by the Contractor including any permit conditions and approvals for the discharge of water generated during the execution of the Work.
9. Other permits required for construction or operation of the dewatering system including the drilling of wells, temporary power drops, etc.
    a. The dewatering plan shall be designed and sealed by a qualified professional engineer registered in the State of Utah. The Contractor will be responsible for selection and payment of the engineer to perform the dewatering system design.

1.4 REFERENCES

A. Utah Department of Environmental Quality, Division of Water Quality Storm Water Program.

1.5 PERMITS

A. Submit a short-term activity exemption application and plan.

Contact Utah Division of Water Quality – General Permit for Construction Dewatering and/or Hydrostatic Testing for details.

http://www.deq.utah.gov/Permits/water/updes/updes_f.htm

B. Dewatering discharge to or across adjacent canals, drains, right-of-way, and private property outside of the designated limits of construction shall not be allowed unless the

Contractor has obtained written approval from agency or property owner having jurisdiction. Provide Agreements with dewatering plan submittal as described in Part 1.3 of this section.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 PREPARATION

A. Furnish, install and prepare for operation, all necessary machinery, appliances and equipment to maintain all structure excavations free from water during construction.

B. Contractor shall provide temporary power sources for all dewatering equipment that requires a power source.

C. Install or use existing well point for dewatering system before initial excavation commences to lower ground water levels. Well point piping to be left after construction for future use.

3.2 STRUCTURE DEWATERING

A. Dewater and dispose of water in such a manner that it does not cause injury to public or private property, or cause a nuisance or a menace to the general public.

B. Comply with Utah Water Quality Standards, latest edition, for discharge of water to surface water.

C. The Contractor will be responsible for devising a system to achieve the required level of dewatering. It is anticipated that this system may incorporate wells, well points, interception trenches, sumps, etc. In addition, design and provide dewatering conveyance system to an approved disposal location. The Contractor shall submit details of this plan as described in Part 1.3 of this Section.

D. Draw and maintain static water level to at least two feet (2’) below the bottom of the excavation prior to excavating below the water table to maintain the undisturbed state of the foundation soils and allow placement of bedding material and backfill to the required density.

E. Remove all groundwater, seepage, stormwater and other water that accumulates in the excavation during construction. All structure excavations shall be kept free of water during construction or until otherwise requested by the Contractor and approved by the Engineer.

F. Prevent softening of the bottom of excavations and the formation of "quick" conditions or "boils" during excavation. The occurrence of such conditions will require over-excavation and subsequent backfilling to soils meeting City and APWA requirements at no additional cost to the Owner.

G. Additional cost for trench bottom stabilization resulting from inadequate dewatering and non-compliance with the performance specifications included herein, as determined by the Engineer, will be incidental to the work.

H. Compact native soil at the bottom of the excavation prior to placing bedding in accordance with City and APWA requirements.

I. Maintain static water level at least two feet (2') below the bottom of the excavation until the specified foundation and structure is placed in accordance with these specifications. Maintain water levels at least two feet (2') below the level of backfill during backfilling operations.

J. Control surface runoff (rainwater, snow melt, irrigation, etc.) to prevent entry or collection of water in excavations.

K. Install and operate a dewatering system so that adjacent structures or property are not endangered by the reduction in the groundwater level.

L. Monitor discharge from dewatering operations for changes in visual or odor components indicating the presence of contaminants including, but not limited to, gasoline and pesticides and other hazardous materials and toxins.

M. Cease dewatering operations and notify Engineer and regulatory agencies immediately upon observation of conditions that may indicate the presence of hazardous contaminants in the dewatering discharge or excavation.

3.3 VERIFICATION

A. Contractor's superintendent shall routinely observe conditions in excavations where dewatering is being performed on a daily basis to verify performance requirements are being met and that conditions in the excavation are in accordance with the Contract Documents.

B. Notify Engineer of any observations that may jeopardize the Work or is not in accordance with the Contract Documents.

C. Based on the verification performed by the Contractor and observations made by the Engineer in accordance with the General Conditions, the Engineer will determine if the performance requirements of the specifications as they relate to dewatering and construction of the improvements are generally being met. If the Engineer determines that the dewatering related Work is not being performed in accordance with the Contract Documents, the Contractor will be notified in accordance with the General Conditions and required to cease construction of the affected Work and revise and resubmit the described dewatering plan with appropriate adjustments to meet the requirements of the Contract Documents and implement any necessary changes to Contractor's dewatering approach and activities at no additional cost to the Owner.

3.4 DEWATERING DISCHARGE

A. Comply with all Local, State & Federal requirements, including (at a minimum):

1. Dewatering discharge water quality and quantity.

2. Dewatering discharge monitoring and sampling at the frequency stipulated in the permits, at any locations required therein.

3. Submit monitoring and sampling report to the appropriate agencies.

B. The Contractor shall be fully responsible for complying with State and Federal water quality requirements. Contractor shall design a dewatering discharge system to achieve such requirements. It is anticipated that stilling basins, geotextile dams, straw bails, silt fences, or siltation channels will be required to meet performance stipulations of the reference permits. Such temporary facilities may be constructed on-site, and will be required to be removed after completion of the Work. Captured sediment must be retained and disposed of at a site furnished by the Contractor. Discharging directly into adjacent surface waters without treatment shall not be permitted.

C. Contractor will not be allowed to utilize the constructed pipelines at or near the structure excavation to convey dewatering flows. Dewatering down the pipe is prohibited. Contractor shall provide temporary, dedicated dewatering pipe when necessary with Contractor's dewatering plan.

D. Work required to comply with water quality and permit requirements are considered incidental and additional payment will not be made for this Work.

3.5 TERMINATION

A. Allow groundwater to return to static level after excavations are backfilled as necessary to prevent floatation of constructed improvements.

B. Prevent disturbance of the compacted backfill and prevent flotation or movement of installed structure.

C. Remove or abandon all temporary improvements associated with the dewatering system in accordance with these specifications and any applicable state and federal rules and regulations.

D. Provide surface restoration as required to repair/replace any surface impacted by dewatering activities to a condition as good or better than preconstruction conditions at no additional cost to the Owner. Surface rehabilitation performed as a result of dewatering activities is considered incidental and no additional payment will be made.

E. At least one well point is to be installed near the lift station that will be protected, capped, and left in place for future use.

F. Comply with any dewatering termination requirements of any Local, State and Federal permits.

3.6 MEASUREMENT AND PAYMENT

A. Separate measurement and payment for the performance of dewatering as described in the Contract Documents will not be made. Performance of this work is considered incidental to other pay items and must be included therein.

END OF SECTION

SECTION 31 23 23
BACKFILLING FOR STRUCTURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backfilling site structures to subgrade elevations.
2. Fill under slabs-on-grade.
3. Fill for over-excavation.

B. Related Sections:

1. Section 31 05 16 – Aggregate Materials
2. Section 31 11 20 – Soil Materials
3. Section 31 22 13 – Rough Grading: Site filling
4. Section 03 30 00 – Cast-in-Place Concrete: Concrete materials.
5. American Public Works Association (APWA) Specifications (latest version)
6. Santaquin City Standards

1.2 REFERENCES

A. ASTM International (ASTM):

1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 foot-pounds/foot^3 (600 kN-m/m^3)).
2. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 foot-pounds/foot^3 (2,700 kN-m/m3)).
4. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
5. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
7. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

1.3 SUBMITTALS

A. Section 01 33 00 – Submittal Procedures: Requirements for submittals.

B. Materials Source: Submit name of imported materials suppliers. Provide materials from same source throughout the course of the project.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Structural Fill: Type M1 as specified in Section 31 05 16.

B. Stabilization Fill: Type M4 as specified in Section 31 05 16.

C. Aggregate Base Course: Type M5 as specified in Section 31 05 16.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify structural ability of unsupported walls to support loads imposed by fill.

3.2 PREPARATION

A. Compact subgrade to density requirements for subsequent backfill materials.

B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with structural fill and compact to density equal to or greater than requirements for subsequent fill material.

C. Scarify subgrade surface to depth of six inches.

D. Proof roll to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

3.3 BACKFILLING

A. Backfill areas to contours and elevations with unfrozen materials.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy subgrade surfaces.

C. Place material in continuous layers as follows:

1. Structural Fill: Maximum eight inches compacted depth.
2. Aggregate Base Course: Maximum six inches compacted depth.

D. Employ placement method that does not disturb or damage other work.

E. Maintain optimum moisture content of backfill materials to attain required compaction density.

F. Slope grade away from building minimum two inches in 10 feet, unless noted otherwise.

G. Make gradual grade changes. Blend slope into level areas.

H. Remove surplus backfill materials from site.

I. Leave fill material stockpile areas free of excess fill materials.

3.4 TOLERANCES

A. Section 01 40 00 – Quality Assurance and Quality Control: Tolerances.

3.5 FIELD QUALITY CONTROL

A. Section 01 40 00 – Quality Assurance and Quality Control: Testing and inspection services.

B. Perform laboratory material tests in accordance with ASTM D1557.

C. Perform in place compaction tests in accordance with the following:

1. Density Tests: ASTM D1556, ASTM D2167, or ASTM D2922.

2. Moisture Tests: ASTM D3017.

D. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

E. Proof roll compacted fill surfaces under slabs-on-grade.

3.6 PROTECTION OF FINISHED WORK

A. Section 01 50 00 –Temporary Facilities and Controls: Protection of existing and installed work.

B. Reshape and re-compact fills subjected to vehicular traffic.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 32 31 13
CHAIN LINK FENCING

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Chain link fencing fabric, posts, braces, anchorage, gates, miscellaneous hardware and appurtenances.

1.2 REFERENCE STANDARDS

A. ASTM International (ASTM) A 53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

B. ASTM A 121: Standard Specification for Zinc-Coated (Galvanized) Steel Barbed Wire.

C. ASTM A 392: Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.

D. ASTM A 641: Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.

E. ASTM F 567: Standard Practice for Installation of Chain-Link Fence.

F. ASTM F 573: Standard Specification for Residential Zinc-Coated Steel Chain-Link Fence Fabric.

G. ASTM F 626: Standard Specification for Fence Fittings.

H. ASTM F 654: Standard Specification for Residential Chain-Link Fence Gates.

I. ASTM F 668: Standard Specification for Polyvinyl Chloride (PVC)-Coated Steel Chain-Link Fence Fabric.

J. Chain Link Fence Manufactures Institute (CLFMI) Product Manual for Chain Link Fence Installation.

1.3 SUBMITTALS

A. Drawings: Indicate plan layout, grid, size and spacing of components, accessories, fittings, anchorage, and post section.

B. Data: Submit manufacturer's installation instructions and procedures, including details of fence and gate installation.

C. Submit sample for fence fabric and typical accessories.

PART 2 PRODUCTS

2.1 GENERAL

A. Galvanizing: Class 3 per ASTM A 121.

B. Steel: Schedule 40 per ASTM A 53.

C. Concrete: Class 3000 minimum, per Cast-in-Place Concrete Section.

2.2 CHAIN LINK FABRIC

A. 11-gauge steel wire fabric for all fences equal to or less than sixty (60) inches in height and 9-gauge for fences over sixty (60) inches coated as follows:

1. Zinc coating per ASTM A 392 requirements.

B. Unless indicated otherwise, use chain link fabric that has approximately two (2) inches square mesh and coated after fabrication.

C. Knuckle finish top edge and twist and barb bottom edge of fabric less than sixty (60) inches wide. For fabric sixty (60) inches or grater in width, knuckle both top and bottom edges. Provide fabric that barbing has been done by cutting the wire on the bias.

D. If indicated, insert slats in fabric.

2.3 BARBED WIRE

A. Two strand, 12-½-gauge wire with 14-gauge, 4-point round barbs spaced approximately five (5) inches on center.

2.4 TENSION WIRES AND FABRIC TIES

A. Tension Wires: 7-gauge galvanized coil spring steel wire per ASTM A 641 requirements.

B. Fabric Fasteners: 9-gauge galvanized or 6-gauge aluminum wire, or approved non-corrosive metal bands, for ties to fasten fabric to posts, rails, and gate frames. Fasten fabric to bottom tension wire spaced twenty-four (24) inches on center.

2.5 TRUSS OR TENSION BARS

A. Galvanized steel rod 3/8-inch diameter for truss or tension bars used in trussing gate frames and line posts adjacent in end, corner, slope, or gate posts. When used in trussing line posts, provide adjustment by means of galvanized turnbuckles or other suitable tightening devices.

B. Tension Bars:

1. Galvanized high carbon steel bars not smaller than 3/16-inch by ¾-inch for tensions bars to fasten fabric to end and corner posts and gate frames. Provide

one (1) tension bar for each end post and two (2) for each corner and pull post per section of fabric.

2. Use tension bar bands made from heavy pressed galvanized steel spaced on fifteen (15) inch centers to secure tension bars to posts.

2.6 POSTS, CAPS, RAILS, COUPLINGS

A. Posts: Galvanized Schedule 40 steel, at the indicated length.

B. Caps: Pressed galvanized steel or malleable iron designed for fit securely over post ends forming a weather tight closure. Where a top rail is used, provide cap to permit passage of top rail. H section posts do not require caps.

C. Top, Intermediate, and Bottom Rails: Galvanized steel, in lengths as required. Provide joint couplings to connect rails securely. Provide means for attaching top rail securely to each end, corner, line, slope, and gate posts.

D. Joint Coupling: Galvanized steel, six (6) inches long minimum for each joint. One (1) coupling in five (5) shall have expansion spring. Couplings shall be outside sleeve type with bore of sleeve true to maintain adjacent lengths of rail in alignment.

Table 1 – Posts, Frames, Stiffeners, Rails

Proposed Use	Nominal Type and Size
End, corner, slope, and gate posts for single gates 6 feet or less in width and double gate 12 feet or less in width for: 1. Fence less than 72 inches high 2. Fence 72 inches or higher	 2 ½" OD Pipe 2-7/8" OD Pipe
Gate posts for single swing gate over 6 feet, but not over 13 feet in width and double swing gates over 12 feet, but not over 26 feet in width or for all slide gates with leaves larger than 6 feet	4" OD Pipe
Gate posts for single swing gates over 13 feet, but not over 18 feet in width and double swing gates over 26 feet, but not over 36 feet in width; backstop posts	6-5/8" OD Pipe
Gate posts for single swing gates over 18 feet in width and double swing gates over 36 feet	8-5/8" OD pipe
Frame for gates	1-5/8" OD pipe
Stiffeners for gates	1-¼" OD pipe
Line posts for fence 72 inches or higher	2-7/8" OD pipe
Line posts for fences less than 72 inches high	2-3/8" OD pipe
Top Rail	1-5/8"OD pipe or 1-½"x1 5/8" H
Bottom Rail	7-gauge, coiled spring steel tension wire

2.7 FITTINGS AND HARDWARE

A. Unless indicated otherwise, galvanize fittings and hardware.

B. Rivets: Make all hardware attachments with galvanized steel rivets.

2.8 SUPPORT OR EXTENSION ARM

A. Use support or extension arms for barbed wire that are of a type that can be attached to the tops of the posts and carry the number of wires indicated.

B. Use only support arms on the fence foe barbed wire that are capable of supporting a 250-pound vertical load at the end of the arm without causing permanent deflection.

C. Single support arms are to be integral with a top post weather cap and have a hole for passage of the top rail when required.

2.9 GATES

A. Residential gates: Refer to ASTM F 654 requirements.

B. Provide additional horizontal and vertical members to ensure proper gate operation and for attachment of fabric, hardware and accessories.

C. Assemble gate frames and attach hardware by welding or by using fittings and rivets to make rigid connections. Use same fabric as for fence. Install fabric with stretcher bars to gate frame at not more than fifteen (15) inches on center.

D. Provide diagonal cross-bracing consisting of 3/8-inch diameter adjustable length truss rods on gates where necessary to prevent frame from sagging or twisting.

2.10 GATE HARDWARE

A. Hinges: Pressed steel or malleable iron to suit gate sizes, non-lift-off type, offset to permit 180-degree gate opening. Provide minimum of one pair of hinges for each leaf.

B. Latch: Forked steel type or plunger-bar steel type to permit operation from either side of gate. Provide locking device and padlock eye as integral part of latch.

C. Keeper: Provide keeper for all vehicle gates which automatically engages the gate leaf and holds it in the open position until manually released.

D. Gate Stops: Mushroom type or flush plate with anchors set in concrete to engage the center drop rod or plunger bar.

2.11 ALTERNATIVE FINISHES

A. Where a colored finish other than galvanized is desired, the following shall apply:

1. All metal posts, caps, rails, and hardware (excepting fabric) shall be painted.

2. Where paint is applied to a galvanized surface, the paint shall be a modified phenolic alkyd type (Valley Paint V-101 or approved equal) or an acrylic type (Valley Paint 2532 Valcryl or approved equal) or Aquapon. The color shall be black to match color of vinyl clad fencing.

3. Where paint is applied directly to a metal surface (non-galvanized), an industrial strength steel primer shall first be applied per manufacturer's specifications. The steel surface shall be properly prepared prior to painting by first grinding all welds smooth and even, insuring that no holes or pits are present due to welding or any other cause, removing all rust and corrosion, and then applying primer.

PART 3 EXECUTION

3.1 PREPARATION

A. Coordinate utility location. Follow Coordination Section.

B. Excavate per Excavation Section requirements.

C. Refer to ASTM F 567 requirements and CLFMI products manual for chain link fence installation.

D. Protect existing trees.

E. Limit the amount of clearing and grading along the fence line to permit proper installation.

3.2 LAYOUT OF WORK

A. Accurately locate and stake location and points necessary for installation of fence and gates.

B. General arrangements and location of fence and gates are indicated. Install except for minor changes required by unforeseen conflicts with work of other trades.

3.3 INSTALLATION OF POSTS

A. Space line posts as follows:

1. Tangent sections to 500 feet radius: 10 feet maximum.
2. 200 feet radius to under 500 feet radius: Eight feet maximum.
3. 100 feet radius to under 200 feet radius: Six feet maximum.
4. Under 100 feet radius: Five feet maximum.

B. Provide pull posts at 500 feet maximum intervals. Changes in line of 30 degrees or more are considered corners.

C. Set all posts to true line and grade in concrete bases or in approved pipe sleeves or sockets. Check for vertical and horizontal alignment.

D. Posts shall have concrete bases of at least ten (10) inches in diameter. Place a minimum of six (6) inches concrete below each post. Depth of post in concrete shall be as follows:

1. Line Posts: 18 inches.
2. End, Pull, Corner, and Gate Posts of less than 6 inches Diameter: 24 inches
3. Gate posts: 30 inches.

E. Where posts are required to be set in concrete walls or masonry, set sockets for the posts to a depth of at least 18 inches. Use sockets that consist of lengths of 0.048-inch galvanized metal pipe sleeves, with an inside diameter sufficient to allow the posts to fit loosely therein. Coat the inside of the socket and outside of the posts with an approved bituminous paint. Caulk the posts securely in place with lead wool.

3.4 INSTALLATION OF BRACE ASSEMBLIES

A. Attached horizontal brace rail from the mid-point of end, pull, corner, or gate posts to the mid-point of the first ensuing line post as a compression member. Install braces from top of said line posts back to the bottom of the end, pull, corner, or gate post with steel truss rods and turnbuckles so posts are plumb when diagonal truss rod is under proper tension.

3.5 INSTALLATION OF RAILS

A. Install rails level and plumb with grade between posts and attached to posts before stretching fabric. Top rails shall form continuous brace from end-to-end of each run of fence.

3.6 INSTALLATION OF FENCE FABRIC

A. Place fence fabric on the security side of posts unless otherwise specified. Place fabric approximately one (1) inch above the ground. Maintain a straight grade between posts by excavating high pints of the ground. Filling depressions with soil will be permitted only upon approval of Engineer.

B. Stretch the fabric taut and securely fasten to posts. Fasten to end, gate, corner, and pull posts. Secure stretcher bars with metal bands spaced at fifteen (15) inch intervals. Cut the fabric and fasten each span independently at all pull and corner posts. Fasten to line posts with tie wire, metal bands, or other approved methods at fifteen (15) inch intervals. Attach the top edge of fabric to the top rail or tension cable at approximately twenty four (24) inches intervals. Attach bottom tension wire to fabric with tie wires at twenty four (24) inch intervals and secure to the end of pull posts with brace bands.

C. Draw barbed wire to assure minimum sag at high temperature and no breakage at low temperature. Connect the wires and arms by means of 0.142-gauge galvanized wire stays.

3.7 INSTALLATION OF GATES

A. Install gates plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation.

3.8 REPAIR DAMAGED COATING

A. Grind smooth and wire brush all welds made after galvanizing to remove loose or burned zinc coating, after which neatly coat the areas with 50-50 solder or as otherwise directed by the Engineer. Make repairs to abraded or otherwise damaged zinc coating in a similar manner. Replace PVC coating.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 33 05 60
PRECAST CONCRETE UTILITY STRUCTURES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Precast concrete vaults.

B. Miscellaneous precast concrete structures for utility use.

C. Bedding and cover materials.

D. Section Exclusions:
   1. Precast concrete manholes which shall be in accordance with Santaquin Public Works Standard Specifications Division 5 and Standard Drawing S-1.
   2. Precast concrete boxes and catch basins which shall be in accordance with Santaquin Public Works Standard Specifications Division 13 and Standard Drawings SD-1 and SD-22

1.2 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 318 - Building Code Requirements for Structural Concrete.
   2. ACI 350 - Code Requirements for Environmental Engineering Concrete Structures.
   3. ACI 530/530.1 - Building Code Requirements for Masonry Structures and Specifications for Masonry Structures.

B. ASTM International (ASTM):
   1. ASTM A48 - Standard Specification for Gray Iron Castings.
   2. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   3. ASTM A536 - Standard Specification for Ductile Iron Castings.
   4. ASTM C33 - Standard Specification for Concrete Aggregates.
   5. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   6. ASTM C150 - Standard Specification for Portland Cement.
   7. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   8. ASTM C443 – Joints for Circular Concrete Sewer and Culvert Pipe using Rubber Gaskets.

9. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.

10. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.

11. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.

12. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals.

13. ASTM C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joints Sealants.

14. ASTM D3753 - Standard Specification for Glass-Fiber-Reinforced Polyester Manholes.

1.3 DESIGN REQUIREMENTS

A. Equivalent strength: Based on structural design of reinforced concrete as outlined in American Concrete Institute (ACI) 350.

B. Design of Lifting Devices for Precast Components: In accordance with ASTM C913.

C. Design of Joints for Precast Components: In accordance with ASTM C913.

D. Watertight precast reinforced air-entrained concrete structures designed to ASTM C890 American Association of State Highway and Transportation Official (AASHTO) HL93 live loading and installation conditions and manufactured to conform to ASTM C913.

E. Minimum 28-day Compressive Strength: 5,000 psi (pounds per square inch).

F. Honeycombed or re-tempered concrete is not permitted.

1.4 SUBMITTALS

A. Section 01 33 00 – Submittal Procedures: Requirements for submittals.

B. Shop Drawings: Indicate structure locations, elevations, dimensions, reinforcing requirements, and sizes and elevations of penetrations.

C. Product Data: Submit cover and frame construction, features, configuration, dimensions.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' experience.

1.6 QUALITY ASSURANCE

A. Perform work in accordance with the Owner's current adopted Standards and the contract Drawing and Specifications.

1.7 DELIVERY, STORAGE AND HANDLING

A. Section 01 60 00 – Product Requirements: Product storage and handling requirements.

B. Comply with precast concrete manufacturer's instructions for unloading, storing and moving precast concrete structural products.

C. Store precast concrete structures to prevent damage to Owner's property or other public or private property. Repair property damaged from materials storage.

D. Mark each precast structure by indentation or waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers shown on Drawings to indicate its intended use.

PART 2 PRODUCTS

2.1 MANHOLES AND STRUCTURES

A. Manhole and Structure Sections: In accordance with Santaquin Public Works Standard Specifications Division 5 and Standard Drawing S-1.

B. Precast Vaults and Boxes: Conform to ASTM C-858 with a minimum wall thickness of eight inches.

C. Design concrete mix to produce required concrete strength, air-entrainment, watertight properties, and loading requirements.

2.2 FRAMES AND COVERS

A. Manufacturers: In accordance with Santaquin Public Works Standard Specifications Division 5 and Section 5.06.

1. D&L Foundry
2. EJ
3. Barry Pattern and Foundry Co., Inc.
4. Campbell Foundry Co.
5. McKinley Iron Works
6. Neenah Foundry Co.
7. Substitutions: Section 01 60 00 – Product Requirements.

B. Product Description: In accordance with Santaquin Public Works Standard Specifications Division 5 and Section 5.06.

C. Size: As indicated on the Drawings.

2.3 COMPONENTS

A. Manhole and Structure Steps: Polypropylene plastic covered galvanized steel reinforced bar rungs; 1/2-inch diameter, meeting ASTM C478, ASTM D4101, and ASTM A615.

B. Grout: As specified in Section 03 30 00 - Cast-in-Place Concrete.

C. Manhole and Structure Gaskets: Conform to ASTM C-443, or Ram-Nek Sealant or approved equivalent.

D. Manhole and Structure Connectors: Conform to ASTM C923.

E. Bedding: Structural Fill aggregate material as specified in Section 31 05 16.

2.4 CONFIGURATION

A. Manholes: In accordance with Santaquin Public Works Standard Specifications Division 5 and Standard Drawing S-1.

B. Other Structures:

1. Shape: As indicated on Drawings.

C. Clear Inside Dimensions: As indicated on Drawings.

D. Design Depth: As indicated on Drawings.

E. Piping Connections: As indicated on Drawings.

F. Clear Cover Opening: 30 inches diameter minimum, and as indicated on Drawings.

G. Grade Rings: As indicated on Drawings.

H. Steps: 12 inches wide, 12 inches on center vertically, set into manhole and structure wall as indicated on Drawings.

2.5 FOUNDATION AND BACKFILL MATERIALS

A. Foundation: Structural fill type as specified in Part 2.1(a) of Section 31 05 16 and the Geotechnical Report.

B. Backfill: Granular backfill type as specified in Part 2.1(b) of Section 31 05 16 and the Geotechnical Report.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify existing conditions are as shown in Contract Documents before starting work.

B. Verify items provided by other sections of Work are properly sized and located.

C. Verify built-in items are in proper location, and ready for roughing into Work.

D. Verify correct size of structure excavation.

3.2 PREPARATION

A. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.

B. Do not install structures where site conditions induce loads exceeding structural capacity of structures.

C. Inspect precast concrete structures immediately prior to placement in excavation to verify structures are internally clean and free from damage. Remove and replace damaged units.

3.3 INSTALLATION

A. Excavation and Backfill:

1. Excavate for structures in accordance with Section 31 23 16 in location and to depth shown. Provide clearance around sidewalls of structure for construction operations.
2. When groundwater is encountered, prevent accumulation of water in excavations. Place manholes and structures in dry trench.
3. Where possibility exists of watertight structure becoming buoyant in flooded excavation, anchor structure to avoid flotation.

B. Place base pad, trowel top surface level.

C. Place structure sections plumb and level, trim to correct elevations, anchor to base pad.

D. Install structures supported at proper grade and alignment as shown on Drawings.

E. Backfill excavations for structures in accordance with Section 31 23 23.

F. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour to form continuous drainage channel as indicated on Drawings.

G. Set cover frames and covers level without tipping, to correct elevations.

H. Coordinate with other sections of Work to provide correct size, shape, and location.

I. Subgrade stabilization includes over excavation followed by installing 3- to 4-inch diameter, clean, angular cobbles into the subgrade to create a working surface over the exposed subgrade. Following subgrade stabilization, an approved separation geotextile should be placed over the stabilized subgrade to prevent intrusion of fine-grained subgrade soils into the structural fill. Structural fill may then be placed and compacted over the geotextile.

3.4 PRECAST CONCRETE MANHOLE AND STRUCTURE INSTALLATION

A. Lift precast components at lifting points designated by manufacturer.

B. When lowering structures into excavations and joining pipe to units, take precautions to ensure interior of pipeline and structure remains clean.

C. Set precast structures bearing firmly and fully on structural fill bedding, compacted in accordance with provisions of Section 31 23 23 or on other support system shown on Drawings.

D. Assemble multi-section structures by lowering each section into excavation. Lower, set level, and firmly position base section before placing additional sections.

E. Remove foreign materials from joint surfaces and verify sealing materials are placed properly. Maintain alignment between sections by using guide devices affixed to lower section.

F. Joint sealing materials may be installed on site or at manufacturer's plant.

G. Verify structures installed satisfy required alignment and grade.

H. Remove knockouts or cut structure to receive piping or conduit without creating openings larger than required to receive pipe or conduit. Fill annular space with grout and caulk perimeter of opening.

I. Cut pipe to finish flush with interior of structure.

J. Shape inverts through manhole and structures as shown on Drawings.

3.5 FRAME AND COVER INSTALLATION

A. Set frame and cover 2 inches above finished grade for manholes and structures with covers located within unpaved areas to allow area to be graded away from cover beginning 1 inch below top surface of frame.

3.6 FIELD QUALITY CONTROL

A. Section 01 40 00 – Quality Requirements, Section 01 70 00 – Execution and Closeout Procedures: Field inspecting, testing, adjusting, and balancing.

B. Test concrete manhole and structure sections in accordance with ASTM C497.

C. Test cast-in-place concrete in accordance with Section 03 30 00 – Cast-in-Place Concrete.

D. Vertical Adjustment of Existing Manholes and Structures:

1. Where required, adjust top elevation of existing manholes and structures to finished grades shown on Drawings.

2. Reset existing frames, grates and covers, carefully removed, cleaned of mortar fragments, to required elevation in accordance with requirements specified for installation of castings.

3. Remove concrete without damaging existing vertical reinforcing bars when removal of existing concrete wall is required. Clean vertical bars of concrete and bend into new concrete top slab or splice to required vertical reinforcement, as indicated on Drawings.

4. Clean and apply sand-cement bonding compound on existing concrete surfaces to receive cast-in-place concrete in accordance with Section 03 30 00.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 33 30 00
SEWER BYPASS PUMPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Sewage bypass pumping requirements, controls and procedures.

1.2 RELATED SECTIONS

A. Section 01 10 00 – Work Summary

B. Section 01 33 00 – Submittals

C. Section 01 52 00 – Construction Facilities

1.3 DESCRIPTION AND GENERAL REQUIREMENTS

A. Furnish all labor, materials, equipment, and incidentals required to maintain continuous and reliable sanitary sewer service during construction.

B. During various phases of the Work, it will be necessary to construct and maintain temporary bypass sewers to maintain continuous and reliable sewer flow in all pipes, including individual service connections. Various phases of the Work that may require the implementation of temporary bypass sewers.

C. Contractor shall construct and maintain all temporary bypass sewers and be responsible for all bypass pumping of high and low sewage flow that may be required to prevent backing up of sewage and allow appropriate conditions for proper inspection, rehabilitation, testing or drainage during the work.

1.4 SUBMITTALS

A. The design, installation, operation, and maintenance of the temporary bypass pumping system shall be the Contractor's responsibility. The bypass system shall meet the requirements of all codes and regulatory agencies having jurisdiction.

B. Submit a sewage bypass control plan that includes the following:

1. The locations of pumps;
2. Schedule when bypass pumping operations will occur, coordinated with work sequence;
3. Contingency plan for equipment or power failure, including manual and automatic controls
4. Emergency notification protocols and sequence of contact persons in case of primary system failure.

5. Spill response plan;
6. Operation and maintenance manual of equipment;
7. Sewer plugging location and type of plugs;
8. Proposed number, type, and capacity of bypass pump(s) and piping and power requirements. Include product data on all equipment to be used;
9. Number, size, material, location and method of installation of suction piping;
10. Number, size, material, method of installation and location of installation of discharge piping;
11. Calculations of pumping system friction losses (including suction losses), suction and discharge velocities. Include a pump curve with a system curve showing pump operation for high and low suction conditions;
12. Provide the seal of a Professional Engineer (PE) licensed in the State of Utah on the bypass pumping drawings and supporting engineering calculations.
13. Temporary pipe supports and anchoring required;
14. Example notification flyer for notifying impacted residents and stakeholders.

PART 2 PRODUCTS

2.1 BYPASS PRODUCTS

A. All pumps shall be automatic self-priming units that do not require the use of foot-valves or vacuum pumps in the priming system. The pumps may be electric or diesel powered. All pumps must be designed and constructed to allow dry running for long periods of time to accommodate the cyclical nature of effluent flows. Sewer bypass systems shall meet city noise ordinances.

B. Bypass piping shall be constructed of jointless pipe. The pipe joints and pressure rating shall match the pumping conditions. Aluminum irrigation type piping or glued polyvinyl chloride (PVC) pipe shall not be permitted. Discharge hose shall only be allowed in short sections. The pipe shall be free of punctures or any leaks throughout the operation.

PART 3 EXECUTION

3.1 DEMONSTRATION

A. The bypass control system shall adequately and continuously convey all wastewater flows during construction. The Contractor shall be responsible for continuity of sanitary sewer service to each facility and residence connected to the section of sewer main during the execution of the work.

B. Prepare contingency plans for equipment or power failure and unexpected conditions. Sewage bypass pumping shall provide for 100 percent backup redundancy.

C. Prepare all necessary diversions and modifications in accordance with the submitted plan.

D. Provide independent temporary power sources for sewage bypass pumping equipment. Provide all necessary temporary electrical service to machinery and provisions for backup power generation. Provide experienced and qualified personnel to operate and maintain system function throughout the bypassing period. Provide all temporary lighting and safety control systems.

E. Startup testing procedure:

1. Air pressure test the bypass piping to 15 psi and hold for 15 minutes prior to putting the pipe into service

2. Contractor shall operate the sewage bypass system for a 2-hour trial period during expected peak flows under observation by the Owner or Engineer before bringing the bypass system online. If the bypass system fails or deficiencies are noted, the contractor shall correct the problem(s) and restart the trial period at no additional cost to the Owner. Trial period shall continue until the Owner and Engineer deem it to be completed

F. If discharging to new downstream sewers, verify that they have passed leakage testing and are approved for receiving wastewater flows.

G. Bypass of sewage shall be in enclosed piping. Wastewater is not permitted to flow in open trenches. Temporary gravity flow diversions through structures with partial pipes and/or baffles with concrete channels may be permitted with Owner and Engineer approval.

H. Install discharge piping in a manner to provide safe and reliable service, without disrupting public access and incorporation with the Traffic Control Plan. Report spillage immediately to Owner and Engineer. Isolate the contaminated area from the public and execute containment and remediation procedures.

3.2 BYPASS PUMPING SYSTEM REQUIREMENTS

A. The bypass systems shall have sufficient capacity to pump peak hourly flows that are seen at the Lift Station, it is assumed that the peak hourly flow will be **1,500 Gallons Per Minute (GPM)**. An updated peak hourly flow will be determined after analysis of the existing flow meter data. A safety factor of 1.2 shall be used when sizing pumps, pipes, and all other apparatuses.

B. The bypass shall be made by temporarily plugging the line to be isolated at the upstream manhole and pumping the flow into a downstream manhole.

C. Sewage flow shall be maintained at all times around the construction operations. Contractor shall be responsible for the continuity of sanitary sewer service to each connection within the sewer reach being rehabilitated during execution of the work.

D. Bypass control systems shall not surcharge or in any way affect the full operating capacity of the upstream or downstream trunk sewers. Surcharging shall be defined as depth of flow above the pipe crown.

E. The bypass system shall have a high level switch to initiate a local horn, an alarm/phone dialer, and emergency light or beacon. The contractor shall provide automatic stop/start controls for each pump.

F. The contractor shall take all necessary precautions and shall be liable for all cleanup, damages and resultant fines caused by sewage bypass system spills.

G. Implement contingency plans for equipment or power failure and unexpected flow conditions. These plans shall be provided to the Engineer prior to operation.

H. Implement all necessary diversions and modifications in accordance with submitted plan.

I. During all bypass pumping operation, the Contractor shall protect lift stations, sewer mains, and all sewer services from damage inflicted by any equipment. The Contractor shall be responsible for all physical damage to sewer system facilities caused by human or mechanical failure.

J. When completed with work, Contractor shall return flow slowly to normal to prevent surge.

3.3 MONITORING

A. The Contractor shall provide a qualified operator for continuous manned monitoring of the bypass pumping, and in no circumstance should the system be left without human surveillance, surveillance shall occur both upstream and downstream of the point being isolated as well as service lines that require bypassing in addition with an alarm/phone dialer. Bypass pumping at night will be permitted only with Owner and Engineer approval.

B. The responsible operator selected to monitor the bypass system shall be proficient in operating the bypass pumping and piping system. These individuals shall have experience in properly switching pipes, pumps, and power sources quickly in case of failures and unclogging pumps in case they become plugged.

3.4 SEQUENCING AND SCHEDULING

A. Prior to starting construction, the contractor and the bypass pumping team will have a meeting to discuss the bypass pumping plan with the owner and the engineer.

3.5 TERMINATION

A. Remove equipment and appurtenances upon termination of sewage bypass control activities and restore disturbed area to original condition.

B. Clean any sewer mains or manholes which have been surcharged.

END OF SECTION

SECTION 40 05 10
PIPE AND FITTINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Pipe and Fitting Systems

B. Pipe Penetration Seals

C. Couplings

D. Mechanical Joint Restraints

E. Thrust Block

F. Hardware

G. Pipe Testing

H. Valve Boxes

I. Location Wire and Marking Tape

1.2 REFERENCES

A. ASTM D1330: Standard Specification for Rubber Sheet Gaskets

B. ASTM D5162: Standard Specification for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates

C. ASTM F2164: Standard Specification for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems using Hydrostatic Pressure

D. ASTM F2618: Standard Specification for Chlorinated Poly Vinyl Chloride (CPVC) Pipe and Fittings for Chemical Waste Drainage up to 220°F

E. International Building Code (IBC), current edition adopted by local jurisdiction.

F. Uniform Plumbing Code (UPC), current edition adopted by local jurisdiction.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00 Submittal Procedures.

B. Submit manufacturer's certification under provisions of Section 01 33 00 Submittal Procedures that product(s) meet or exceed the specified requirements.

C. Submit manufacturer's installation instructions.

D. Submit shop drawings for all piping four inches in diameter or larger. Shop drawings shall show accurate dimensions of the piping system to be provided including, but not limited to pipe, valves, fittings, connection points to equipment, support system, and appurtenances for all above ground or exposed piping systems. Drawings shall also show connection types. Piping less than four inches in diameter shall be routed as shown on the Plans and to avoid conflicts.

E. Submit restraint calculations for all below ground piping where mechanical restraint will not be provided. Reference Paragraph 2.19 herein.

F. Submit all testing results. Results shall clearly identify which pipe segment was tested (start and end point of piping run), pipe diameter, pipe length, and pipe material. Submitted test data shall include any calculations performed.

1.4 QUALITY ASSURANCE

A. Reference Section 01 40 00 Quality Assurance and Quality Control.

B. The Contract Documents represent the minimum acceptable standards for the Work. All Work shall conform fully in every respect to the requirements of the respective parts and sections of the Contract Documents. The entire unit shall be the Manufacturer's standard product, but shall be modified, redesigned, furnished with special features or accessories, made of materials or provided with finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of the Contract Documents.

C. Fabrication shall be done in compliance with all applicable ASTM standards or equivalent international standards.

D. Welding

1. All welders and welding operators shall be qualified by an ASME-approved testing laboratory before performing any welding under this section. Qualification tests shall be in accordance with Section IX, Article III of the ASME Boiler and Pressure Vessel Code. Welders and welding operators shall be qualified for making groove welds in Type 316L stainless steel pipe in position 6G for each welding process to be used. Welders must be certified and be able to provide proof that less than six months have elapsed since performing a qualified weld.

2. Qualification tests may be waived if evidence of prior qualification is deemed suitable by the Engineer. The manufacturer or Contactor shall retest any welders at any time the Engineer considers the quality of the welder's work substandard. When Engineer requests the retest of a previously qualified welder, the labor costs for the retest will be at the Owner's expense if the welder successfully passes the test. If the welder fails the retest, all cost shall be

at the Contractor's sole expense, including any rework required due to substandard work, as defined by the Engineer.

1.5 PROJECT RECORD DOCUMENTS

A. Reference Section 01 70 00 Closeout Requirements.

B. Accurately record actual location of constructed pipe lines, valves, thrust blocks, support systems, and any other component of the piping system in relation to existing permanent benchmarks and/or improvements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Reference Section 01 60 00 Product Requirements.

B. Unload, store, and load pipe in a manner that prevents shock, damage, or excessive exposure to sunlight and weather.

C. Coated pipe shall be shipped on padded bunks with nylon belt tiedown strips or padded banding.

PART 2 MATERIALS

2.1 GENERAL

A. All piping materials, fittings, solvents, primers, welds, or other products and appurtenances used for potable water applications must comply with NSF 61 and be certified Lead-Free.

B. Definitions

1. Pipe installation conditions:

a. Buried: from first exterior joint outside the structure and continuing below grade. Includes piping under slabs between other transition points when in direct contact with the soil and piping encased in concrete or CDF that is not integrally connected to the structure.

b. Embedded: from first exterior joint outside of the structure to transition point where pipe becomes "inside/exposed" or "submerged". Includes piping passing through or embedded in concrete walls / slabs of structures, grout fills inside structures, masonry, etc.

c. Inside/Exposed: above slabs (within structures) or above grade (exterior) and exposed to air at all times. After transition from "embedded" or "buried".

d. Submerged: from top of wall downward in a liquid containing structure, after transition from "embedded" or "inside/exposed".

2. Lining vs. coating:

   a. Lining applies only to the interior of the pipe and associated appurtenances. Coating applies only to the exterior of the pipe and associated appurtenances.

3. Restraint:

   a. Mechanical restraint: requires the use of an appurtenance or a specific joint type to physically prevent the separation of a joint within the pipe system. Joint types which qualify as mechanical restraint include flanged, socket/solvent welded, butt/fusion welded, welded, threaded, grooved, or Vanstone flanged. Specific mechanical joint restraint appurtenances are described in the pipe system data tables.

   b. Soil restraint: sufficient pipe length is provided either side of a joint such that the friction between the soil and the pipe is sufficient to prevent joint separation under the testing conditions for the piping system. A separate appurtenance or specific joint type is not required to physically hold the joint together.

   c. Reference Paragraph 2.19 herein for additional information.

4. Wall spools vs. sleeves:

   a. Wall spools: connect directly to the process piping and directly convey the process liquid or gas.

   b. Wall sleeves: provide an opening for the process pipe to pass through. The annular space between the sleeve and the process pipe shall be filled as required by the Plans.

   c. Reference the Plans and Paragraphs 2.6 and 2.7 herein for additional information.

2.2 PIPE SCHEDULE

A. The Pipe Schedule is included in the Plans.

2.3 PIPE MATERIAL, JOINTS, AND FITTINGS

A. Reference the appendices for product data tables.

B. Reference Section 40 05 20 Double Containment Piping for single and double-wall containment chemical piping.

C. Filed modification of fittings is not acceptable.

D. All threaded joints shall utilize PTFE tape.

2.4 GASKETS

A. Reference the appendices for product data tables.

2.5 COUPLINGS

A. Reference the appendices for product data tables.

2.6 WALL SPOOLS

A. Wall spools shall incorporate a statically cast thrust collar ring, which is positions to accommodate cast-in-place concrete placements, as shown on the Plans.

B. ANSI/AWWA C150 and C151, ductile iron with connection end type compatible with connecting piping and valving and coordinated with shop drawings and Plan requirements.

C. Minimum lay length 24 inches or as shown on drawings. 350 minimum working pressure,

D. Lining shall be epoxy to match pipe system DI02.

E. Coating shall be as follows:

CONDITION	COATING SYSTEM REQUIRED[A]
Completely embedded in concrete.	System D-1, "Metal, Concrete Encased"
Partially embedded in concrete and extending into a liquid-containing structure. Includes spools which are partially buried, partially embedded in concrete, and partially extended into a liquid containing structure.[B]	System C-1, "Submerged and Intermittently Submerged Metal"
Partially embedded in concrete and extending into a structure that does not contain liquid. This includes spools which are partially buried, partially embedded in concrete, and partially extended into a non-liquid containing structure.	System B-1, "Interior Metal and Piping, Non-Submerged"
Partially embedded in concrete and extending outside of a structure and are exposed only to air	System A-1, "Exterior Metal and Piping, Non-Submerged"

[A]See Section 09 96 00 High Performance Coatings for additional information.

[B] Unless specifically allowed by the Engineer, all spools which extend into a liquid-containing structure shall be coated with System C-1 even if they are above the maximum water surface elevation.

2.7 WALL SLEEVES

A. Reference the Plans for wall sleeve material and construction requirements.

2.8 PIPE PENETRATION SEALS

A. All modular mechanical penetration seals shall be Model S-316 Link-Seal as manufactured by Garlock, or approved equivalent.

1. Seal Element Material: EPDM synthetic rubber; ASTM D20000 M3 BA 510
2. Hardware shall be 316 SS
3. Seal shall be watertight
4. Seal size shall accommodate inlet piping and sleeve opening
5. Backfill remaining annular space with non-shrink, waterproof grout where indicated on the Plans.

B. Manhole adaptors as called out on the Plans shall be KOR-N-SEAL as manufactured by NPC, Inc. or approved equivalent.

1. Adaptor must meet ASTM C923 specifications.

2. Seal shall provide a flexible watertight seal of the pipe to the manhole or concrete structure. No adhesives or lubricants shall be employed in the installation of the connector into the manhole.

3. All hardware shall be stainless steel. Stainless steel elements of the connector shall be totally non-magnetic Series 304 Stainless, excluding the worm screw for tightening the steel band around the pipe which shall be Series 305 Stainless. The work screw for tightening the steel band shall be torqued by a break-away torque wrench and set for 60-70 inch/lbs.

4. The connector shall be of a size specifically designed for the pipe material and size being installed.

2.9 THRUST BLOCKS

A. Concrete for thrust blocks shall conform to Section 03 30 00 Cast-in-Place Concrete of these Specifications.

B. Reference the Plans for additional thrust block requirements.

2.10 HARDWARE

A. Unless otherwise shown or specified:

1. All buried nuts, bolts, and washers shall be zinc plated for corrosion protection.

2. Mechanical joint T-bolts shall be lugged (Corten style). All bolts shall be manufactured in accordance with ANSI/AWWA C111/A21.11.

3. Exposed, embedded, or submerged nuts, bolts, and washers shall be 304 or 316 stainless steel.

4. During assembly of interior piping, provide aluminum based anti-seize lubricant on all bolt threads.

2.11 VALVE BOXES

A. Provide adjustable cast iron valve boxes and lid, as shown on the Plans.

B. Provide PVC plastic valve lid insert (beneath the lid) to retain gravel and debris from entering the valve box.

1. Manufacturer: Sealing Systems, Inc. Valve Box Inserts, or equal.

2.12 PIPE SADDLE TAPS

A. For ductile iron pipe, 2- to 30-inch diameter: Ford Style FC202 with double-wide stainless steel band and fusion epoxy coated body, ROMAC Style 202S, or approved equivalent. 150 psi minimum working pressure. Hardware shall be stainless steel.

B. For PVC, CPVC, or polyethylene pipe, 12-inch diameter and smaller, and for chemical service: Spears Manufacturing Company Schedule 80 Clamp-on Saddles or approved equivalent. O-rings shall be compatible with pipe contents. Hardware shall be stainless steel. 150 psi minimum working pressure. Provide socket or threaded outlet connection as required by connecting pipe system. All components of the saddle shall be compatible with the chemical(s) utilized within the process piping.

C. For PVC pipe, up to 30-in diameter, for non-chemical service: Ford Style FC202 with double-wide stainless steel band and fusion epoxy coated body, ROMAC Style 202S, or approved equivalent. 150 psi minimum working pressure. Hardware shall be stainless steel.

D. For stainless steel pipe, Schedule 10S to Schedule 40: ROMAC Style 306 or approved equivalent. All metal components, including hardware, shall be 304 stainless steel. Gasket shall be NBR or as required for compatibility with the process liquid. Saddle shall meet the requirements of ANSI/AWWA C800. Minimum working pressure of 150 psi.

2.13 HOT TAPPING SLEEVE

A. Hot tapping shall only be provided where specifically noted on the Plans or as otherwise deemed acceptable by the Engineer.

B. Hot tapping style stainless steel sleeve shall have a minimum working pressure rating of 150 psi. Sleeves shall be sized to the outside diameter of the existing pipe to be tapped with a water outlet size as called out on the Plans. Fasteners shall be Type 304, Grade 18-8, stainless steel, and be a minimum size of ¾ inch. Tightening nuts shall be positioned on the flange side of the tapping sleeve. Flanges shall conform to AWWA C207, Class D, with 150 lb. drill hole pattern, and be stainless steel, Grade 18 8, Type 304. Gasket material shall be approved for potable water service per NSF standards. Product manufacturer shall be Ford FAST style tapping sleeve, Romac tapping sleeve, or approved equivalent.

2.14 PIPE CAPS

A. Provide mechanically restrained MJ or flanged ductile iron end caps for pipe abandonment, or where specifically noted on the Plans. Pipe caps shall be coated to match the adjacent pipe system. Caps shall meet the requirements of ASTM A536, ANSI/AWWA C153/A21.53, and ANSI/AWWA C111/A21.11.

2.15 LOCATING WIRE AND MARKING TAPE

A. All buried piping shall have marking tape and locating wire. Provide a valve box at pipe termination point for accessing locating wire.

B. Locating Wire:

1. Locating wire used in open trench construction shall be #12 AWG high strength copper clad steel with minimum 450 lb. break load. Wire shall be insulated with high density polyethylene (HDPE) insulation intended for direct bury. Minimum thickness shall be 30 mil. Insulation shall be color coded as described herein.

    a. Manufacturer: Copperhead 1230-HS or equal

2. Wire connectors shall be specifically manufactured for use in underground locate wire installation. Connectors shall be dielectric silicon filled to seal out moisture and corrosion and shall be installed in a manner so as to prevent any uninsulated wire exposure. Non-locking friction fit, twist on (aka wire nuts), or taped connectors are prohibited.

    a. Manufacturer: Copperhead Snakebite Locking Connectors or equal

C. Contractor shall demonstrate correct installation to the engineer by performing a locate/conductivity test for each pipe run.

D. Marking Tape:

1. Material: 75 mm (3 inch), 4 mil polyethylene.

2. Color: marking tape shall be color-coded as described herein.

3. Labeling: Label marking tape with the designated pipe use as described herein using 1-1/2 inch minimum black lettering in all capital letters.

    a. All natural gas, electric power lines, communication/signal lines, potable water, non-potable water, and air lines shall be labeled as such.

    b. Chemical lines shall be custom labeled to reflect the actual chemical contained within the piping. Submit proposed labeling to Engineer for review.

    c. All other process pipe types shall be labeled as “SEWER”.

E. Color Code:

1. Natural gas: yellow

2. Electric power lines: red

3. Communication or signal lines: orange

4. Potable water: blue

5. Non-potable water: purple

6. Chemical: white

7. Air: yellow

8. All other piping: green

2.16 PIPE INSULATION AND JACKETING

A. Match existing insulation and jacketing where connecting to existing systems.

B. Underground Piping:

1. Unless specifically noted otherwise, all buried piping that has less than 4-ft of cover based on final grade shall be provided with DOW Highload 40 insulation in sufficient thickness to equate to 4-ft of bury.

2. Where specifically denoted on the Plans, provide cellular glass pipe insulation. Jacketing shall be precut to fit the contour of the surface to which it is to be applied. Precut sections shall allow for 2-inch overlap. All laps shall be sealed with a glove coat of manufacturer's seal coat. Butt straps shall be identical in all respects and appearance to the basic jacket material. Insulation thickness, and number of layers required, shall be as recommended by the manufacturer to maintain the required temperature noted on the Plans.

a. Manufacturer: Owens Corning FOAMGLAS insulation pipe shells with Owens Corning "PITTWRAP HS Jacketing" or equal.

C. Exterior Exposed and Interior Exposed Piping Insulation

1. Protection against freezing: All exterior exposed piping shall be provided with electric heat trace and insulation unless specifically noted otherwise.

2. Interior exposed piping shall only be provided with insulation where specifically denoted on the Plans.

3. Insulation Requirements:

a. Where operating temperatures are between 0- and 850-degress Fahrenheit, provide performed fiberglass pipe insulation with factory applied all-service vapor-retarder jacket with a self-sealing longitudinal closure lap and butt strips. Insulation thickness, and number of layers required, shall be as recommended by the manufacturer to maintain the required temperature as noted on the Plans. Where nested insulation is utilized, the exposed ends of the insulation shall be coated in mastic. Install in accordance with all manufacturer's requirements and recommendations.

i. Manufacturer: JM Micro-Lok HP, Owens Corning SSL II, or equal.

b. Where flanges, couplings, elbows, tees, or valves prevent the nesting of pipe insulation from creating a continuous seal, provide molded PVC covers. PVC is required to provide a vapor barrier for non-continuously sealed nested insulation under metal jacketing systems.

i. Manufacturer: Zeston 2000/300 fittings, or equal

D. Exterior Exposed and Interior Exposed Piping Insulation Jacket

1. All exterior exposed piping shall be jacketed with an Aluminum, PVC, or stainless-steel jacket, as noted on the Plans.

2. Provide protective jacketing over interior exposed insulation where specifically noted on the Plans.

a. Material:

i. Aluminum: Johns Manville Aluminum Jacket with Ell-Jacs Aluminum Elbow Covers

ii. Stainless Steel: Johns Manville stainless steel Jacket with Ell-Jacs Stainless-Steel Elbow Covers

iii. PVC: UV resistant Zeston 30 mil PVC Jacketing with Zeston 2000/300 fittings, or equal.

2.17 DIELECTRIC UNIONS AND INSULATION FLANGES

A. Dielectric unions or insulating flanges shall be used to separate all dissimilar metal pipe connections and wherever buried ferrous metal pipe transitions to above grade.

2.18 LUBRICANTS

A. Pipe lubricants shall be supplied by the pipe manufacturer. No substitutes for lubricants from other manufacturers will be allowed.

2.19 RESTRAINT

A. Provide restrained joints, unless otherwise specified.

B. Acceptable types of restraint include:

1. Fittings (regardless of location): All fittings shall be restrained by mechanical joint restraint.

2. Valves (regardless of location): All valves shall be restrained by mechanical joint restraint.

3. Dead Ends (regardless of location): All dead ends (e.g., caps, blind flanges…etc.) shall be restrained by mechanical joint restraint.

4. Couplings (regardless of location): All couplings shall be restrained by mechanical joint restraint unless specifically noted otherwise.

    a. For buried pipe, straight coupling joints shall be mechanically restrained unless the coupling does not fall within the required minimum restrained length on both sides of the joint. Where mechanical restraint is required, provide external restraint appurtenance.

5. Buried or Embedded Pipe:

    a. Thrust Blocks: Provide thrust blocks under all buried valves and at other locations specifically indicated on the Plans.. Thrust blocks shown at fittings, valves, and dead ends shall be provided in addition to mechanical joint restraint.

        i. Provide bearing area against undisturbed earth.

        ii. Place thrust blocks such that fitting can be removed at a later date without damage to the pipeline.

        iii. Place concrete so no concrete touches the nuts and bolts of the fitting or valve, and the nuts and bolts can be removed and replaced without removing any concrete.

        iv. Reference the Plans for additional requirements.

    b. Mechanical Restraint: provide mechanical restraint appurtenance at all joints within the calculated minimum restrained length.

    c. Restraint by Soil Friction: restraint due to soil friction is sufficient for all pipe-to-pipe joints outside of the calculated minimum restrained length.

    d. Minimum Restrained Length: The minimum restrained length is a calculated distance from the end of a fitting, valve, or dead end (e.g., cap, blind flange…etc.) for which all joints must be mechanically restrained. Unless otherwise required by local, state, or federal codes and regulations, the minimum restrained length shall be as follows:

        i. For horizontal pipes with four feet of cover and a test pressure of 150 psi, the minimum restrained length shall be as shown in the following table:

Pipe Size (in)	Minimum Restrained Length					
	Fitting Angle				Valve or Dead End	Branch of Tee[a]
	11.25°	22.5°	45°	90°		
4	2	3	5	12	38	0
6	2	4	7	17	53	0
8	3	5	9	22	68	2
10	3	5	11	25	80	14
12	3	6	13	30	93	28
14	4	7	14	33	104	40
16	4	8	16	37	116	52
18	4	9	17	41	126	63
20	5	9	19	44	137	74
24	5	11	21	51	155	93
30	6	12	25	60	180	119
36	7	14	28	68	202	142
42[b]	6	12	25	59	122	89
48[b]	7	13	27	64	131	99

(a) Note, either side of the tee run shall be fully restrained with a mechanical restraint appurtenance for a minimum of 10 feet.

(b) Assumes pipe is ductile iron. If alternate material is used, Contractor shall submit revised minimum restrained length calculations for review by the Engineer.

e. Where the excavation/trench extends into an area that has groundwater at any time of the year, the minimum restrained lengths do not apply, and all joints and fittings shall be fully restrained utilizing mechanical restraint appurtenances.

f. Contractor shall provide additional mechanical restraint appurtenances for pressure testing purposes. Specifically, where plugs are installed for pressure testing, a dead end is created and all joints within the minimum required restrained length from this plug shall be

mechanically restrained. Contractor shall leave the restraints in place upon completion of the pressure test.

g. Where valves, fittings, or other appurtenances are added to an existing pipeline, the Contractor shall mechanically restrain the existing joints for the minimum required restrained length on all sides of the new component.

h. All joints between a tee and a hydrant/hose bibb shall be fully restrained utilizing mechanical restraint appurtenances regardless of the distance between the tee and the hydrant/hose bibb.

i. Listed lengths are based on a test pressure of 150 psi. To compute the length for a different test pressure for bends, valves, or dead ends, use the following equation, where all lengths shall be rounded up to the nearest foot:

$$Length = \left(\frac{Test\ \ Pr\,e\,ssure}{150}\right)\ (Table\ Value)$$

For tees, consult the Engineer for the minimum required restrained length at different test pressures.

j. Listed lengths assume a well graded condition with little to no fines. If conditions are different, verify minimum restrained lengths with supplier.

k. Contractor shall submit calculations for minimum restrained lengths for the following scenarios, at minimum:

   i. Non-horizontal pipe installations

   ii. Test pressures greater than 150 psi

   iii. If the pipe is wrapped in plastic

   iv. Bury depth is less than four feet

   v. For 42” and 48” pipe, if the pipe material is not ductile iron

   vi. For each expansion or contraction (i.e., reducers) in the piping

l. Where the minimum required restrained length is greater than the straight length of pipe available, Contractor shall notify Engineer as alternate means of restraint (e.g., thrust block, thrust collar with anchors…etc.) are required. Contractor shall provide alternate means of restraint at no additional cost to the Owner.

   i. For tees where the straight run of piping on the branch is insufficient to provide the minimum restrained length, the

straight run of piping on either side of the tee run may require a longer minimum restrained length than 10 feet. Contractor shall notify the Engineer and provide mechanical restraint appurtenances for the length determined by the Engineer for all sides of the tee at no additional cost to the Owner.

6. Interior, Exposed, and Submerged Pipe:

a. Mechanical Restraint: provide mechanical restraint at all joints.

C. All mechanical restraint appurtenances shall be coated with fusion bonded epoxy, unless specifically noted otherwise.

PART 3 EXECUTION

3.1 GENERAL

A. Pipe and associated appurtenance shall be installed in accordance with good trade practice and in strict accordance with the manufacturer's instructions, recommendations, and requirements. The methods employed in the handling and placing of pipe, fittings, and equipment shall be such as to ensure that after installation and testing they are in good condition, as determined by the Engineer.

B. When pipe installation is not progress, block or plug all openings not actively undergoing connection/installation to prevent debris and wildlife from entering the piping.

C. All pipe and fitting joints shall be restrained. Reference Paragraph 2.19 of this Specification.

3.2 EXAMINATIONS

A. Verify excavation meets the requirements of Section 31 23 16 Excavation.

B. Verify that excavations are to required alignment, grades, dry, and not over excavated.

C. Verify that excavation will allow a minimum pipe cover as shown on the Plans and as described elsewhere in the Specifications.

1. Where specific pipe elevations are not stated and new piping is to be connected to existing pipelines which have less than the minimum required cover: connect to existing pipeline and angle pipe, as necessary, to achieve cover requirements.

2. Where specific pipe elevations are provided, if the cover is less than four feet, provide insulation as described in this Section.

D. Verify materials delivered to the site meet the requirements of these Technical Specifications. Examine materials for defects or damage. Defective or damaged products shall not be incorporated into the Work.

E. Examine existing piping locations and structures where connections are to be made. Notify Engineer of any discrepancies.

F. Verify equipment locations. Notify Engineer, prior to ordering parts, if modifications are required to properly connect the piping to the equipment.

3.3 NATURAL GAS PIPING INSTALLATION

A. Install in accordance with local gas codes and requirements, including the gas provider's requirements for materials, trenching, backfilling, testing, etc.

3.4 PLUMBING INSTALLATION: WATER AND DRAIN PIPING

A. Install horizontal runs at a minimum slope of 1/8-inch per foot, unless noted otherwise, and in accordance with local plumbing codes.

3.5 COMPRESSED AIR (INSTRUMENT AIR) PIPING INSTALLATION

A. Routing of instrument air piping is the responsibility of the Contractor in conformance with Contract Documents. Air piping shall be routed to prevent conflict with all other components of the Work. Piping and fittings must conform to ASME B31.1.

B. Piping and fittings must meet the design temperature, pressure, and environment of the system.

C. Horizontal pipe runs should be installed at a grade of at least one inch per 100 feet and drain valves should provide at low points.

D. Provide isolation ball valves at all branch lines and at each instrument.

E. Provide fittings, pipe hangars, brackets, clamps, dielectric unions, etc. as necessary to route piping to point of use.

F. Contractor is required to provide adequately sized piping/tubing as required to operate the instruments on each branch line. Unless otherwise indicated, provide ½-inch diameter minimum for a line serving a single instrument; 1-inch diameter minimum for any line serving two or more instruments.

G. Unless otherwise noted for underground installation use HDPE or stainless-steel materials.

H. Unless otherwise noted for aboveground installation should use Stainless steel, painted copper, or aluminum.

I. Air-flush all lines prior to connection to instruments or valves.

J. Tubing:

1. Provide HDPE or Polypropylene ½-inch OD x 3/8-inch ID poly tubing between instrument isolation valve and the instrument or valve. Poly tubing shall be no

longer than 3 ft and shall have adequate slack to allow disconnection from the instrument or valve.

2. Contractor shall route tubing such that access to valves, process piping, equipment and electrical components is not limited or obstructed.

3.6 BURIED AND EMBEDDED PIPE INSTALLATION

A. All connections with existing piping or components shall be potholed and checked for material, size, connection type, and space available for connection prior to making the connection. Contractor shall provide all parts necessary for the connection at no additional cost to the Owner. Contractor shall submit verification to the Engineer of all potholes confirming that no conflicts exist, and that Contractor has all parts and equipment required for the connection readily available onsite. Verification shall be submitted at least 24 hours in advance of the planned connection date and time.

B. Contractor shall coordinate all outages and/or shutdowns required for connecting to existing piping currently in use per Section 01 32 17 Work Sequence.

C. Remove all water from excavation.

D. Install pipe in accordance with the manufacturer's recommendations and requirements.

E. Utilize proper tools for cutting and beveling pipe ends. Join pipe using manufacturer's recommended tools designed for this task.

F. Clean and prepare pipe joint using manufacturer's recommended gasket and lubricant.

G. Utilize proper tools to complete joint. For bell and spigot pipe, assure that the plain end is inserted "home" in the bell.

H. Assure that no dirt or other foreign material is allowed in the pipeline. Plug all pipe ends with watertight plugs when leaving the pipe unattended.

I. Complete trenching and backfilling for utilities in accordance with Section 31 23 33 Backfilling and Compacting for Utilities.

J. Install pipe fittings so a constant alignment and grade is achieved through all the pipe and fittings between the elevations stated on the Drawings.

K. Install pipelines to the alignments and grades shown on the Drawings.

L. Properly align pipe perforated slots in trench.

M. Enter and exit through structure walls, floors, and ceilings by using penetrations and seals as shown on the Drawings.

N. Pipes passing beneath or through structure footings/foundations shall have a flexible pipe coupling with longitudinal restraint at each location where a pipe leaves or passes

out from beneath a structure to accommodate potential differential settlement between the structure and pipe. Reference the Drawings for additional information.

3.7 INTERIOR, EXPOSED, AND SUBMERGED PIPING INSTALLATION

A. All connections with existing piping or components shall be checked for material, size, connection type, and space available for connection prior to making the connection. Contractor shall provide all parts necessary for the connection at no additional cost to the Owner. Contractor shall submit verification to the Engineer of all connection points confirming that no conflicts exist and that Contractor has all parts and equipment required for the connection readily available onsite. Verification shall be submitted at least 24 hours in advance of the planned connection date and time.

B. Contractor shall coordinate all outages and/or shutdowns required for connecting to existing piping currently in use per Section 01 32 17 Work Sequence.

C. All piping shall be fully supported at all times during and after installation. Equipment or other connected components shall not bear the weight of the piping. No strain shall be induced within the equipment during, or subsequent to, the installation of pipe work. Reference the Plans and Section 40 05 07 Pipe Supports for additional information.

D. Hanging of any pipe from another is prohibited.

E. In erecting the pipe, a sufficient number of unions or flanged joints shall be used to allow any sections or run of pipe to be disconnected without taking down adjacent runs. The Contractor shall provide additional pipe joints as necessary to facilitate delivery and construction of the piping components at no additional cost to the Owner. All additional joints shall be coordinated by the Contractor to prevent conflict with any component of the Work. Contractor shall submit the locations of additional joints to the Engineer for review for all pipes larger than 2-inch in diameter.

F. Flexible couplings shall be installed where shown on the Drawings. Additional flexible couples shall be provided for ease of installation or removal of the pipe at no additional cost to the Owner. Contractor shall coordinate to prevent conflict with any component of the work. Contractor shall submit the locations of additional flexible couplings to the Engineer for review for all pipes larger than 2-inch in diameter.

3.8 PIPE PENETRATION INSTALLATION

A. All penetrations shall be installed with the associated formwork prior to the concrete pour. Blockouts and pour-backs shall not be acceptable unless prior consent is received from the Engineer. Where allowed, blockouts and pour-backs may require additional Work which shall be at the Contractor’s soul expense.

3.9 PIPING INSULATION INSTALLATION

A. General: Pipe insulation shall be continuous and installed on all fittings and appurtenances unless specified otherwise. Installation shall be with full-length units of

insulation and using a single-cut piece to complete a run. Provide jackets for all pipe insulation.

1. Install material in accordance with the manufacturer's written instructions.

2. Locate insulation and cover seams in least visible locations.

3. Do not apply insulation until pipe tests and heat tracing is completed.

4. Do not apply insulation over flanged joints until piping has been brought up to operating temperature and flange bolts have been fully tightened.

5. Remove material such as rust, scale, dirt and moisture from surfaces to receive insulation.

6. Neatly finish insulation at supports, protrusions, and interruptions.

7. Provide insulated dual temperature with vapor retardant jackets with self-sealing laps. Insulate complete system.

8. Stagger joints on multi-layer insulation.

9. Mix mineral fiber thermal insulating cement with demineralized water when used on stainless steel surfaces.

B. Joints: Joints shall have adjacent sections tightly butted with jackets drawn tight and smoothly cemented down on all longitudinal and end laps. Jacket longitudinal laps shall overlap by at least 1-1/2”, unless noted otherwise by the manufacturer. Butt joints shall be sealed with pressure-sensitive vapor barrier tape.

1. Jacket laps, butt strips, and exposed ends of insulation shall be cement sealed using either adhesive or factory-applied, self-sealing system. Jacket laps shall be smooth and without fishmouths.

C. Laps: Unless noted otherwise by the manufacturer, self-sealing laps (1-1/2” minimum) and butt strips (3” minimum width) shall be used for sealing insulation joints. Staple with outward clinching staples on 4” centers on side laps and 4” on centers to both butted jackets for butt strips. If any open gaps occur, add staples and lagging adhesive or replace jacket totally.

1. For cold applications, provide lagging adhesive on all staples.

D. Insulation Support at Hangers:

1. For all piping 1-1/2” in diameter or larger, provide support shield between piping and hanger to prevent damage to the insulation. Shield shall be fabricated of 14-gauge stainless steel sheet metal, unless specifically noted otherwise. Insulation shields and inserts shall be not less than the following lengths.

1-1/2” to 2-1/2” pipe size	10” long
3” to 6” pipe size	12” long
8” to 10” pipe size	16” long
12” and larger pipe size	22” long

2. Provide vapor barrier per insulation manufacturer’s recommendations to prevent condensation.

E. Sleeves and Wall Chases: Insulation on pipes through walls and floors shall be full size and jacketed same as adjacent insulation. Provide a metal jacket over the insulation on pipe passing through sleeves in non-fire rated walls where caulking is required.

1. Where penetrating interior walls, extend the metal jacket 2 inches out on either side of the wall and secure on each end with a band.

2. Provide adequate support on vertical pipe to prevent slipping.

3.10 PIPING COLOR CODE AND IDENTIFICATION

A. General:

1. Unless required otherwise by the Engineer, all exposed process and building piping and accessories shall be identified and painted as specified herein and in conformance with this specification.

2. The following piping materials need not be completely painted with the basic identification color; colored bands may be provided instead for the following:

a. Stainless steel

b. Chrome-plated piping

c. Interior HDPE Chemical Piping

d. Interior PVC/CPVC Chemical Piping

3. Where piping is to be identified with colored bands, a three-band system shall be used. The background color, as identified on the pipe schedule, shall appear in the left and right-most bands, with the secondary color located in the center. For piping with only a single identifying color, a single colored band shall be provided.

4. All PVC piping that extends to the exterior of buildings/structures (i.e., exposed to UV/sunlight) shall be painted completely. Submit to coordinate color with process identification and architectural elements.

5. The entire exposed surface of all other piping and accessories shall be painted according to the color codes indicated in the pipe schedule.

B. Identification Labels:

1. Identify all exposed piping and all piping on each side of each valve; on each side of a branch; on both sides and adjacent to each wall and floor penetration, and at 15 feet on center (maximum spacing between labels).

2. All chemical piping shall be identified a minimum of two (2) times in each interior room.

3. Identification Label Requirements:

a. Name of service as shown on Plans

b. Flow direction arrows

c. Position identification so that it is readily visible from eye level.

d. Block letters neatly stenciled on the finished insulation or pipe with flat black or white enamel contrasting the background pipe color. Label/Text size shall be as noted below. In some instances, as an alternative to painting of identification, an adhesive decal pipe identification system may be acceptable upon review by the Engineer. Contractor shall submit product information for review by Owner and Engineer as an alternative to painted identification.

SIZE OF LETTERS / ARROWS	
Outside Diameter of Pipe or Covering	**Height of Stencil Letter**
¾" to 1¼"	½"
1½" to 2"	¾"
2½" to 6"	1¼"
8" to 10"	2½"
Over 10"	3½"

3.11 PRESSURE TESTING

A. Refer to the Pipe Schedule within the Plans for pipelines which shall be pressure tested, the testing pressure, and testing method.

B. Pressure testing and preparation for pressure testing shall not be done when the temperature is anticipated to be at or below 32°F. Confirm ambient temperatures with Engineer prior to beginning pressure test preparations.

C. Pressure testing shall not be done until all appurtenances required by the Contract Documents, including but not limited to valves, instruments, and pipe supports, have been installed.

D. Pressure taps for test plugs shall be ½-inch FNPT unless otherwise specified.

E. Assure that the trench is properly backfilled and compacted, and thrust blocking has cured for 28 days in order to prevent damage or pipe/fitting movement. Pressure testing shall occur prior to surface restoration and prior to any structure or portion thereof being constructed above the pipe. This may require the pipe to be pressure tested in segments. All pipelines shall pass pressure testing before completing surface repair. If the Contractor chooses to provide surface repair prior to achieving passing pressure tests for all pipes, the Contractor shall bear all costs associated with any additional surface repair which may be required.

F. Provide additional pipe restraint to obtain minimum required restrained length from pipe plugs. See Paragraph 2.19.

G. Remove all construction debris from piping prior to pressure testing. Flush all piping with potable water at a minimum velocity of 2.5 fps. Flushing activities shall continue until flush water appears clean and free of debris, in the opinion of the Engineer. Dispose of water per local, state, and federal requirements.

H. Test Methods:

1. Test Type: G (Gravity)

   a. Per International Plumbing Code if indicated on the Pipe Schedule.

   b. Hydrostatically test the pipeline to 25 psi.

2. Test Type: H (Hydrostatic)

   a. Pressure test HDPE pipe per ASTM F2164-02 “Field Leak Testing of Polyethylene (PE) Pressure Piping Systems using Hydrostatic Pressure”.

   b. For all other pipe materials, fill pipe with water to the pressure shown on piping schedule. Expel all air.

   c. Verify that, in a two-hour (2) test, the pipe does not leak in excess of the allowable leakage, as defined by the following formula:

$$Q = \frac{LD\sqrt{P}}{148{,}000}$$

Where:

Q = allowable leakage (gallons per hour)

L = length of pipe section being tested (feet)

D = nominal pipe diameter (inches)

P = average test pressure during the hydrostatic test (psi)

3. Test Type P (Pneumatic)

   a. Pneumatic testing shall only be allowed where specifically noted as acceptable by the Engineer.

   b. Pneumatic testing, where allowed, shall be per ISPWC Section 501 – Gravity Sewers, Paragraph 3.4.C with pressure as indicated on the Pipe Schedule

4. Certify test results meet these specifications and submit all results and Contractor's certification to the Engineer.

3.12 MANDREL DEFLECTION TESTING

A. If specified in the Pipe Schedule, provide mandrel deflection testing no sooner than 30 days after trench backfill and compaction is completed.

B. Deflection testing shall be conducted and all pipelines shall pass deflection testing before completing surface repair. If the Contractor chooses to provide surface repair prior to achieving passing deflection tests for all pipes, the Contractor shall bear all costs associated with any additional surface repair which may be required.

C. The maximum allowable deflection is to be 5.0% of the nominal pipe diameter.

D. Provide test mandrels with a diameter at least 95% of the actual inside diameter (ID) of the pipe. For pipes with controlled outside diameter, calculate the actual ID of the pipe by taking the average outside diameter (OD) as set by the ASTM standard and subtracting two (2) times the minimum wall thickness as set by the ASTM standard. For pipes with controlled inside diameter, use the ID set by the ASTM standard.

E. Pull the appropriate mandrel through the pipe using one of the following methods:

   1. Pull the mandrel through the pipe by hand. If the pipe will not allow the mandrel to pass, repeat the test from the opposite direction to determine the limits of failure. If the mandrel cannot pass through the entirety of the pipe, the pipe is considered to have failed the deflection test.

   2. As a part of the CCTV inspection, see Section 33 01 00 TV Inspection of Gravity Pipelines, pull the mandrel through the pipe by connecting it in front of the CCTV camera lens at a distance equal to the camera's focal length. Notify Engineer of time and date of test at least 24 hours prior to testing to allow for Engineer, at Engineer's discretion, to witness test. Provide tag line to reverse mandrel and camera should mandrel fail to pass through line. Perform test as a separate step from the CCTV inspection, where required, thus a separate DVD or digital video file record must be made of the mandrel test. Clearly mark tape identifying project name, mandrel test, and the pipe will not allow the mandrel to pass, repeat the test from the opposite direction to determine the limits of failure. If the mandrel cannot pass through the entirety of the pipe, the pipe is considered to have failed the deflection test.

F. Uncover and, if required by the Engineer, remove and reinstall new pipe sections for reaches with excessive deflection (i.e., which have failed the deflection test) or recompact bedding if, in the opinion of the Engineer, existing pipe is not damaged. Retest pipe after any repair work is completed. Do not reinstall damaged pipe.

G. The Owner may conduct additional deflection testing at their own cost prior to expiration of the warranty period. If a pipe is found to have excessive deflection (i.e., fail the deflection test) the Contractor shall uncover and provide new pipe that meets all requirements herein at no additional cost to the Owner. Contractor shall also provide additional testing of the replacement pipe until the pipe passes all required tests at no additional cost to the Owner. Do not reinstall damaged pipe.

3.13 LOCATING WIRE AND MARKING TAPE

A. Place locating wire and marking tape at the locations shown on the plans for the entire length of a pipeline. Repair all cuts and splices in accordance with the manufacturer's recommendations. Assure continuity of all locating wire before submitting final payment. Payment will not be made for pipe where the locating wire does not have electrical continuity.

3.14 DISINFECTION OF POTABLE WATER LINES

A. Provide disinfection of potable water lines in accordance with Section 33 01 11 Disinfection of Water Distribution Lines.

3.15 TOLERANCES FOR SEWER INTERCEPTOR INSTALLATION

A. The sewer interceptor pipe slope shall conform to the slope set forth in the plans. Reverse slope on gravity pipe is prohibited. Manhole flow channels that pond water are unacceptable. Line segments and manholes not meeting these tolerances shall be rejected and replaced at the Contractor’s expense.

B. The horizontal alignment of the pipeline shall conform to +/- 1-foot from true alignment shown on the plans. The pipeline shall also maintain the separation distance requirement from potable water lines shown on the Contract Documents. Line segments not meeting these tolerances and/or requirements shall be rejected and replaced at the Contractor’s expense.

C. The Contractor shall conduct quality control surveys, at each manhole and as needed throughout sewer interceptor installation, to ensure that project requirements and tolerances are satisfied.

APPENDIX A

Pipe System Data Tables

PVCO1

GENERAL DESCRIPTION:	Small-Diameter Gravity PVC Pipe		
SIZE:	Less than or equal to 12-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	PVC	
	MATERIAL STANDARD:	ASTM D1784 Cell Class 12454 ASTM D1785, Type I, Grade 1 (PVC1120)	
	SCHEDULE OR SDR:	Schedule 40	
	PRESSURE RATING OR CLASS:	130 PSI at 73°F	
PIPE JOINTS			
	TYPE:	Solvent weld	
		JOINT STANDARD:	ASTM D2855
		SOLVENT WELD CEMENT STANDARD:	ASTM D2564
		SOLVENT WELD PRIMER STANDARD:	ASTM F656
		PRESSURE RATING:	78 PSI at 73°F
GASKETS			
	N/A		
FITTINGS			
	MATERIAL:	PVC	
		MATERIAL STANDARD:	ASTM D1784 Cell Class 12454
	TYPE:	Socket	
		FITTING STANDARD:	ASTM D2466
		PRESSURE RATING:	78 PSI at 73°F
HARDWARE			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	See pipe schedule for color.		
	See Section 09 96 00 for coating requirements.		
NOTES			
1.	Buried pipe shall be installed in accordance with ASTM F 1668.		
2.	Fabricated fittings are not permitted.		
3.	FNPT fitting shall have external stainless steel reinforcing band.		
4.	Solvent welds shall use solvent cement and solvent primer in accordance with the manufacturer's recommendations.		
5.	Sun damaged or discolored pipe is not acceptable.		

PVC01

GENERAL DESCRIPTION:	PVC SDR 35 Gravity Sewer Pipe		
SIZE:	4- through 15-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	PVC	
	MATERIAL STANDARD:	ASTM D3034, Cell Class 12454 or 12364	
	SCHEDULE OR SDR:	SDR 35	
	PRESSURE RATING OR CLASS:	Pipe Stiffness of 46 PSI	
PIPE JOINTS			
	TYPE:	Integral Bell Joint	
		JOINT STANDARD:	ASTM D3212
GASKETS			
	TYPE:	Elastomeric, factory installed	
		GASKET STANDARD:	ASTM F477
FITTINGS			
	MATERIAL:	PVC	
		MATERIAL STANDARD:	ASTM D3034 SDR 35
	TYPE:	Solvent Weld – See Note 3	
		FITTING STANDARD:	ASTM D 1784 cell class 12454-B
	TYPE:	Push-on Gasketed	
			ASTM D3212 and F1336
HARDWARE			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	N/A – Buried Piping		
NOTES			
1.	Buried pipe shall be installed in accordance with ASTM D2321.		
2.	Sun damaged or discolored pipe is not acceptable.		
3.	Solvent weld fittings shall only be utilized on pipe less-than or equal-to 15-inch nominal diameter. Cement and primer shall be compatible with the pipe material and the pipe contents. Solvent weld shall meet the criteria of ASTM D2855.		
4.	Suitable couplings complying with ASTM specifications shall be used for joining dissimilar pipes or two plain ends of similar pipe only where bell and spigot are not available.		

PVC02

GENERAL DESCRIPTION:	Large-Diameter Gravity PVC Sewer Pipe		
SIZE:	18- through 48-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	PVC	
	MATERIAL STANDARD:	ASTM F679	
	SCHEDULE OR SDR:	SDR 35	
	PRESSURE RATING OR CLASS:	Pipe stiffness of 46 PSI	
PIPE JOINTS			
	TYPE:	Integral Bell Gasket	
		JOINT STANDARD:	ASTM D3212
GASKETS			
	TYPE:	Rubber, factory installed	
		GASKET STANDARD:	ASTM F477
FITTINGS			
	MATERIAL:	PVC, gasketed	
		MATERIAL STANDARD:	ASTM D3034, SDR 35 Wall Thickness
		FITTING STANDARD:	ASTM F1336
HARDWARE			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	N/A – Buried Piping		
NOTES			
1.	Buried pipe shall be installed in accordance with ASTM D2321.		
2.	Sun damaged or discolored pipe is not acceptable.		

PVC03

GENERAL DESCRIPTION:	Small-Diameter Pressure PVC Pipe		
SIZE:	Less than or equal to 8-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	PVC	
	MATERIAL STANDARD:	ASTM D1785 Type 1, Grade 1 (PVC 1120)	
	SCHEDULE OR SDR:	Schedule 80	
	PRESSURE RATING OR CLASS:	250 PSI at 73°F	
PIPE JOINTS			
	TYPE:	Solvent Weld	
		JOINT STANDARD:	ASTM D2855
		SOLVENT WELD CEMENT STANDARD:	ASTM D2564, See Note 5
		SOLVENT WELD PRIMER STANDARD:	ASTM F656, See Note 5
		PRESSURE RATING:	150 PSI at 73°F
GASKETS			
	See pipe schedule for gasket material selection.		
FITTINGS			
	MATERIAL:	PVC	
		MATERIAL STANDARD:	ASTM D1784
	TYPE:	Socket, See Note 3	
		FITTING STANDARD:	ASTM D2467
		PRESSURE RATING:	150 PSI at 73°F
	TYPE:	Threaded, See Note 3	
		FITTING STANDARD:	ASTM D2464
		PRESSURE RATING:	125 PSI at 73°F
	TYPE:	Van Stone Flange, See Note 3	
		FITTING STANDARD:	ASTM D2467
		PRESSURE RATING:	150 PSI at 73°F
HARDWARE			
	Hardware shall be 304SST or as required to be chemically compatible with the liquid to be contained within the piping.		
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	See pipe schedule for color.		
	See Section 09 96 00 for coating requirements.		
NOTES			
1.	Buried pipe shall be installed in accordance with ASTM F 1668 and ASTM D2774.		
2.	Piping, solvent cement, solvent primer, and all other appurtenances shall be certified ANSI/NSF-61 lead free for potable water service applications.		

GENERAL DESCRIPTION:	Small-Diameter Pressure PVC Pipe
SIZE:	Less than or equal to 8-inch nominal diameter
NOTES	
3.	Fitting types shall be as follows, unless specifically noted otherwise: a. Socket fittings shall be provided for all buried applications. b. Threaded fittings shall be provided only where specifically indicated on the plans, or as required for connection to system components. FNPT fitting shall have external SS reinforcing band. Threaded fittings shall not be allowed for sodium hydroxide applications. c. Flanged fittings shall be provided only where necessary to connect to valves or other appurtenances in the piping system. Socket unions shall be used preferentially to Van Stone flanges.
4.	Fabricated fittings are not permitted.
5.	For chemical service: solvent welds shall use a solvent cement and primer that are compatible with the chemical being conveyed in the specific process piping. Submit product information and chemical compatibility. Contractor is ultimately responsible for ensuring chemical compatibility.
6.	Clear PVC (where required on the Plans) shall be UV resistant SCH. 80, “Near Water Clear” as manufactured by Harvel, or approved equal.
7.	Sun damaged or discolored pipe is not acceptable.

PVC04

GENERAL DESCRIPTION:	Buried Pressure PVC Pipe		
SIZE:	4- through 48-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	PVC	
	MATERIAL STANDARD:	ANSI/AWWA C900, ASTM D1784 Class 12454	
	SCHEDULE OR SDR:	DR 25 (up to 48" diameter) DR 18 (up to 30" diameter and where specifically required)	
	PRESSURE RATING OR CLASS:	CL 165 PSI (up to 48" diameter) CL 235 PSI (up to 30" diameter and where specifically required)	
PIPE JOINTS			
	TYPE:	Bell and Spigot Ends	
		JOINT STANDARD:	ASTM D3139
		PRESSURE RATING:	165 PSI (unless specifically noted otherwise)
GASKETS			
	TYPE:	Rubber, factory installed	
		GASKET STANDARD:	ASTM F477
FITTINGS			
	MATERIAL:	Ductile Iron	
		MATERIAL STANDARD:	ANSI/AWWA C111/A21.11
	TYPE:	Mechanical	
		FITTING STANDARD:	ANSI/AWWA C110/A21.10 OR C153/A21.53
		PRESSURE RATING:	350 PSI (up to 24" diameter) 250 PSI (30"- 48" diameter)
HARDWARE			
	Hardware shall be 304SST or as required to be chemically compatible with the liquid to be contained within the piping.		
LINING (FITTINGS ONLY)			
	MATERIAL:	Ceramic epoxy Protecto 401 (amine cured Novalac Epoxy), as manufactured by Pacific States Cast Iron Pipe Company; 40 mils nominal dry film thickness. See Note 3 for Potable Water Applications.	

GENERAL DESCRIPTION:	Buried Pressure PVC Pipe	
SIZE:	4- through 48-inch nominal diameter	
COATING (FITTINGS ONLY)		
	MATERIAL:	Asphaltic coating per ANSI/AWWA C151/A21.51 and ANSI/AWWA C110/A21.10; 1 mil nominal dry film thickness.
MECHANICAL RESTRAINT APPURTENANCES		
	PRODUCT:	Wedge action joint restraint glands shall be rated at 350 psi with a 2:1 safety factor. Gland shall be fusion bonded epoxy coated, minimum dry film thickness 20 mils.
	PRODUCT:	PVC Bell and Spigot Push-On Pipe: EBAA Iron, Inc. Series 1900 or 2800 Megalug, or equivalent. Coat with Mega-Bond liquid thermoset epoxy coating per manufacturer's requirements.
	PRODUCT:	MJ Fittings: EBAA Iron, Inc. Series 2000PV or 2200 Megalug, or equivalent. Coat with Mega-Bond liquid thermoset epoxy coating per manufacturer's requirements.
NOTES		
1.	Buried pipe shall be installed in accordance with ASTM F 1668 and ASTM D2774.	
2.	Unless specifically noted otherwise, integral pipe color shall be blue for potable water, purple for non-potable water (i.e., utility water), and green for all other sewer or process services.	
3.	Protecto 401 shall not be used with potable water. Provided standard thickness cement-mortar lining following ANSI/AWWA C104/A21 for potable water applications. Provide Induron Ceramapure PL 90 lining when noted as epoxy-lined pipe/ fittings for potable water applications.	
4.	Sun damaged or discolored pipe is not acceptable.	

PVC10

GENERAL DESCRIPTION:	Pressure CPVC Pipe		
SIZE:	½- through 8-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	Chlorinated Polyvinyl Chloride (CPVC)	
	MATERIAL STANDARD:	ASTM D1784, Cell Classification 23447 ASTM F441, Type IV, Grade 1	
	SCHEDULE OR SDR:	Schedule 80	
	PRESSURE RATING OR CLASS:	250 PSI at 73°F	
PIPE JOINTS			
	TYPE:	Solvent Weld	
		JOINT STANDARD:	ASTM F439
		SOLVENT WELD CEMENT STANDARD:	ASTM F493, See Note 5
		SOLVENT WELD PRIMER STANDARD:	ASTM F656, See Note 5
		PRESSURE RATING:	250 PSI at 73°F
GASKETS			
	See pipe schedule for gasket material selection.		
FITTINGS			
	MATERIAL:	CPVC	
		MATERIAL STANDARD:	ASTM F439 ASTM D1784 Cell Classification 23447
	TYPE:	Socket, See Note 3	
		FITTING STANDARD:	ASTM F439
		PRESSURE RATING:	150 PSI at 73°F
	TYPE:	Threaded, See Note 3	
		FITTING STANDARD:	ASTM F439
		PRESSURE RATING:	125 PSI at 73°F
	TYPE:	Van Stone Flange, See Note 3	
		FITTING STANDARD:	ASTM F441
		PRESSURE RATING:	150 PSI at 73°F
HARDWARE			
	Hardware shall be 304SST or as required to be chemically compatible with the liquid to be contained within the piping.		
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	See pipe schedule for color.		
	See Section 09 96 00 for coating requirements.		

GENERAL DESCRIPTION:	Pressure CPVC Pipe
SIZE:	½- through 8-inch nominal diameter
NOTES	
1.	Buried pipe shall be installed in accordance with ASTM F 1668 and ASTM D2774.
2.	Piping, solvent cement, solvent primer, and all other appurtenances shall be certified ANSI/NSF-61 lead free for potable water service applications.
3.	Fitting types shall be as follows, unless specifically noted otherwise: a. Socket fittings shall be provided for all buried applications. b. Threaded fittings shall be provided only where specifically indicated on the plans, or as required for connection to system components. FNPT fitting shall have external SS reinforcing band. Threaded fittings shall not be allowed for sodium hydroxide applications. c. Flanged fittings shall be provided only where necessary to connect to valves or other appurtenances in the piping system. Socket unions shall be used preferentially to Van Stone flanges.
4.	Fabricated fittings are not permitted.
5.	For chemical service: solvent welds shall use a solvent cement and primer that are compatible with the chemical being conveyed in the specific process piping. Submit product information and chemical compatibility. Contractor is ultimately responsible for ensuring chemical compatibility.
6.	Sun damaged or discolored pipe is not acceptable.

PE01

GENERAL DESCRIPTION:	Buried Small-Diameter High Density Polyethylene Pipe (HDPE)		
SIZE:	Less than or equal to 3-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	HDPE, PE 4710	
	MATERIAL STANDARD:	AWWA C901, ASTM F 714	
	SCHEDULE OR SDR:	DR 9 (minimum)	
	PRESSURE RATING OR CLASS:	250 PSI	
PIPE JOINTS			
	TYPE:	Socket Fusion Weld	
		JOINT STANDARD:	ASTM F2620
		PRESSURE RATING:	250 PSI
	TYPE:	Butt Heat Fusion Weld	
		JOINT STANDARD:	ASTM D3261
		PRESSURE RATING:	250 PSI
GASKETS			
	See pipe schedule for gasket material selection.		
FITTINGS			
	MATERIAL:	HDPE	
		MATERIAL STANDARD:	ASTM D3350, ASTM D3035
	TYPE:	Socket Fusion Weld	
		FITTING STANDARD:	ASTM D2683, ASTM D3035
		PRESSURE RATING:	250 PSI
	TYPE:	Butt Heat Fusion Weld	
		FITTING STANDARD:	ASTM D3261
		PRESSURE RATING:	250 PSI
HARDWARE			
	See Paragraph 2.10 of this Specification Section.		
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	See pipe schedule for color.		
	See Section 09 96 00 for coating requirements.		
NOTES			
1.	Pipe shall conform to the outside-diameter dimensions for iron pipe size (IPS).		
2.	Brass compression couplings or pack joints with stainless steel inserts shall be provided in lieu of stainless steel where specifically noted on the Plans. Manufacturer shall be Ford, Mueller, or approved equal.		
3.	No joints, other than butt heat fusion weld joints, are allowed beneath building slabs and foundations.		
4.	Sun damaged or discolored pipe is not acceptable.		

PE02

GENERAL DESCRIPTION:	Buried Large-Diameter High Density Polyethylene Pipe (HDPE)		
SIZE:	4- through 36-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	HDPE	
	MATERIAL STANDARD:	AWWA C906, ASTM D3035, ASTM F714	
	SCHEDULE OR SDR:	DR 11 (minimum)	
	PRESSURE RATING OR CLASS:	200 psi (minimum)	
PIPE JOINTS			
	TYPE:	Butt Heat Fusion Weld	
		JOINT STANDARD:	ASTM D3261
		PRESSURE RATING:	250 PSI (DR 9); 200 PSI (DR 11)
GASKETS			
	See pipe schedule for gasket material selection.		
FITTINGS			
	MATERIAL:	HDPE, PE4710	
		MATERIAL STANDARD:	ASTM 3350
	TYPE:	Butt Heat Fusion Weld	
		FITTING STANDARD:	ASTM D3261
		PRESSURE RATING:	200 PSI (DR 11)
HARDWARE			
	See Paragraph 2.10 of this Specification Section.		
NOTES			
1.	Sun damaged or discolored pipe is not acceptable.		

DI01, DI02, DI03 & DI04

GENERAL DESCRIPTION:	Ductile Iron Pipe		
SIZE:	3- through 48-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	Ductile Iron	
	MATERIAL STANDARD:	ANSI/AWWA C150/A21.50 ANSI/AWWA C151/A21.51 (mechanical, grooved, and push-on joints) ANSI/AWWA C115/A21.15 (flanged)	
	SCHEDULE OR SDR:	See Note 2	
	PRESSURE RATING OR CLASS:	350 PSI, See Note 10	
PIPE JOINTS – See Note 4			
	TYPE:	Push-on (3”-36”)	
		JOINT STANDARD:	ANSI/AWWA C111/A21.11
		PRESSURE RATING:	350 PSI
	TYPE:	Mechanical (3”-24”)	
		JOINT STANDARD:	ANSI/AWWA C110/A21.10 OR C153/A21.53
		PRESSURE RATING:	350 PSI (3”-24”)
	TYPE:	Flanged (3”- 48”)	
		JOINT STANDARD:	ANSI/AWWA C115/A21.15 ANSI B16.1
		PRESSURE RATING:	250 PSI (minimum)
	TYPE:	Grooved (3”-36”)	
		JOINT STANDARD:	AWWA C606 (3”-24” diameter), See Note 11
		PRESSURE RATING:	150 PSI (minimum)
GASKETS			
	See pipe schedule for gasket material selection.		
FITTINGS – See Note 4			
	MATERIAL:	Ductile Iron	
		MATERIAL STANDARD:	ANSI/AWWA C150/A21.50 ANSI/AWWA C151/A21.51 (mechanical, grooved, and push-on joints) ANSI/AWWA C115/A21.15 (flanged)
	TYPE:	Mechanical (4”-48”)	

GENERAL DESCRIPTION:	Ductile Iron Pipe		
SIZE:	3- through 48-inch nominal diameter		
FITTINGS – See Note 4			
		FITTING STANDARD:	ANSI/AWWA C110/A21.10 OR C153/A21.53
		PRESSURE RATING:	350 PSI
	TYPE:	Flanged (3”- 48”)	
		FITTING STANDARD:	ANSI/AWWA C115/A21.15
		PRESSURE RATING:	250 PSI (minimum)
	TYPE:	Grooved (3”-36”) – See Note 9	
		FITTING STANDARD:	AWWA C606, See Note 11
		PRESSURE RATING:	150 PSI (minimum)
HARDWARE			
	See Paragraph 2.10 of this Specification Section.		
LINING (PIPE AND FITTINGS)			
DI01			
	MATERIAL:	Cement mortar	
		MATERIAL STANDARD:	ANSI/AWWA C104/A21.4
DI02			
	MATERIAL:	Epoxy	
		MATERIAL STANDARD:	See Note 6
DI03			
	MATERIAL:	Glass Lining	
		MATERIAL STANDARD:	See Note 7.
DI04			
	MATERIAL:	Unlined	
		MATERIAL STANDARD:	N/A
COATING (PIPE AND FITTINGS)			
INSTALLATION CONDITION			
	BURIED:	Exterior coated with asphaltic coating. ANSI/AWWA C151/A21.51 and ANSI/AWWA C110/A21.10 ANSI/AWWA C153/A21.53; 1 mil.	
	EMBEDDED:	See Note 1.	
	INSIDE/EXPOSED:	See Note 1.	
	SUBMERGED:	See Note 1.	
MECHANICAL RESTRAINT APPURTENANCES			
	PRODUCT:	Mechanical Joints: EBAA Iron, Inc. Series 1100 Megalug or approved equivalent. Less than or equal 16” diameter – 350 psi rating, 2:1 safety factor. Greater than 16” diameter – 250 psi rating, 2:1 safety factor. Coat with Mega-Bond liquid thermoset epoxy coating per manufacturer’s requirements.	

GENERAL DESCRIPTION:	Ductile Iron Pipe	
SIZE:	3- through 48-inch nominal diameter	
	PRODUCT:	Push-On Pipe Joints (up to 24" diameter): Field-Lok gaskets as manufactured by US Pipe, SureStop 350 gaskets as manufactured by McWane Ductile, or approved equal. Gasket shall be from the same manufacturer as the pipe.
MECHANICAL RESTRAINT APPURTENANCES		
	PRODUCT:	Grooved Joints: Victaulic Grooved Coupling Style 31, with Grade M FlushSeal gasket, and primed with phenolic alkyd primer or as required to coordinate with pipe coating system.
NOTES		
1.	See Section 09 96 00 High Performance Coatings for coating requirements. See pipe schedule for color. Reference Paragraph 2.6 for clarification on coating systems to be used for various installation locations, in particular, locations where a single spool of pipe has multiple installation conditions.	
2.	Pipe class (i.e., wall thickness) shall be as required to accommodate the required joint type, working pressure, and test pressure. Reference the Pipe Schedule for test pressure requirements.	
3.	Where taps are shown on fittings, tapping bosses shall be provided.	
4.	Unless specifically noted otherwise, the following pipe and fitting joints shall be provided at the locations indicated: a. Buried: Push-on, Mechanical, or Flanged b. Embedded: Mechanical or Flanged c. Submerged: Flanged Inside/Exposed: Flanged or Grooved	
5.	Gray-iron threaded flanges shall not be permitted.	
6.	Protecto 401 shall not be used with potable water. Provide Induron Ceramapure PL 90 lining for potable water applications requiring epoxy lining.	
7.	Glass Lining Requirements for Ductile Iron Pipe and Fittings: i. Glass-lined ductile iron pipe shall be manufactured per ASTM B1000. ii. The glass lining applied to pipe and fittings shall be vitreous material that is hard, smooth, continuous, and formulated to prevent the adherence of grease in sludge and scum lines, and to resist the adherence of crystalline metal salt deposits (Struvite and Vivionite) to sludge and centrate lines. It shall be applied to properly prepared pipe and fittings using accepted industry standards, and shall be tested per applicable standards, including ASTM D-5162-01, NACE RP 0188-99, and SSPC Coating Manual, Volume 1, Section XIV. iii. Lining shall be U.S. Pipe SG-14, Fast Fabricators/Waterworks Manufacturing MEH-32, or approved equal. iv. The applicator shall have a minimum of 5 years of successful experience in the application of high temperature glass and porcelain coatings. v. The lining material shall consist of vitreous and inorganic material applied to the internal surfaces that have been prepared by blasting. The lining shall be applied in a minimum of two (2) coats, separately applied and separately fired. The items shall be exposed to a maturing	

GENERAL DESCRIPTION:	Ductile Iron Pipe
SIZE:	3- through 48-inch nominal diameter
	temperature of approximately 1400° F, at which point the vitreous and inorganic materials melt and fuse to the base metal, forming an integral molecular bond with the base metal surface. Subsequent coatings will be in similar manner, forcing an integral molecular bond with the base coat. The entire finished coating shall be a minimum of 10 mils (.010) and a maximum of 25 mils (.025") as tested with a micro test or other acceptable dry film thickness gauge. The finished lining shall be able to withstand a strain of 0.001 inch/inch (the yield point of the base metal) without damage to the glass. vi. The lining shall have a hardness of 5-6 on the MOHS scale, and a density of 2.5-3.0 grams per cubic centimeter as measured by ASTM D-792. The glass lining shall be capable of withstanding an instantaneous thermal shock of 350° F. differential without crazing, blistering or spalling. It shall be resistant to corrosion of between PH-3 and PH-10 at 125° F. There shall be no- visible loss of surface gloss to the lining after immersing a production sample in an 8 percent sulfuric acid solution at 148° F for a period of 10 minutes. When tested according to ASTM C-283, it shall show a weight loss of not more than 3 milligrams per square inch. vii. Per ASTM D-5162-01, NACE RP 0188-99, and SSPC Coating Manual, Volume 1, Section XIV, the glass lining shall be tested by “low voltage, wet sponge, non-destructive holiday detection unit,” with only isolated voids permitted due to casting anomalies and which represent less than 0.01 percent of the total glassed surface. Test procedure and acceptance criteria shall be per the attachment “MP-9.2, Porcelain Enamel Continuity Testing,” and documentation shall be furnished with each shipment of material listing the test results by identifying "mark or “tag” numbers. viii. For flanged and grooved piping, the finished glass lined pipe shall not deviate more than 0.01875 inch per foot of length from a centerline perpendicular to the square pipe end or flange face. For bell and spigot piping, the finished glass lined pipe shall not deviate more than 0.03125 inch per foot of length from a centerline perpendicular to the square pipe end. ix. Handle pipe according to lining manufacturer’s recommendations. x. Taps and welds shall be done before lining. Field cut and repair field cuts in accordance with manufacturer’s recommendations.
8.	Pipe manufacturer shall be McWane Ductile, U.S. Pipe, or approved equal.
9.	Mechanical grooved pipe couplings and fittings, as manufactured by Victaulic Company of America or approved equivalent. Grooved pipe couplings and fittings shall conform to the following requirements. Grooved end product manufacturer to be ISO-9001 certified. Grooved flange adapter: Coupling shall be a Victaulic Style 341 grooved flange adapter or approved equivalent. The coupling shall have a ductile iron body with nitrile gaskets or orange enamel coating and 316 SS bolts and nuts.
10.	All flanged ductile iron pipe shall be rated to 250 PSI, unless specifically noted otherwise. Where required, flanged pipe with a nominal diameter less than or

GENERAL DESCRIPTION:	Ductile Iron Pipe
SIZE:	3- through 48-inch nominal diameter
	equal to 24 inches shall be rated to 350 PSI by using a specialty gasket whose rating is supported by performance testing as described by AWWA C115.
11.	Pipe barrels shall conform to the requirements of ANSI/AWWA C151/A21.51 (minimum class 53, subject to manufacturing tolerances and additional wall thickness for larger diameters, as may be required).

SST01

GENERAL DESCRIPTION:	Large-Diameter Type 304L Stainless Steel Pipe		
SIZE:	2- through 30-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	304L Stainless Steel	
	MATERIAL STANDARD:	ANSI B36.19 ASTM A312, seamless pipe	
	SCHEDULE OR SDR:	10s	
	PRESSURE RATING OR CLASS:	150 PSI (minimum)	
PIPE JOINTS – See Note 5			
	TYPE:	Butt Weld – See Note 4	
		JOINT STANDARD:	See Note 4
		PRESSURE RATING:	150 PSI (minimum)
	TYPE:	Van Stone Flange	
		JOINT STANDARD:	Class 150 or Class 300 Van Stone type flanges with stainless steel stub ends, ASTM A240 Type 316L "as-welded grade", conforming to MSS SP 43, wall thickness same as pipe.
		PRESSURE RATING:	150 PSI (minimum)
	TYPE:	Grooved	
		JOINT STANDARD:	AWWA C606
		PRESSURE RATING:	150 PSI (minimum)
GASKETS			
	See pipe schedule for gasket material selection.		
FITTINGS – See Note 5			
	MATERIAL:	304L Stainless Steel, 10s	
		MATERIAL STANDARD:	ASTM A403, Grade WP304L, Class W
	TYPE:	Butt Weld – See Note 2, Note 4	
		FITTING STANDARD:	Dimension per MSS SP-43 and ANSI B16.9.
		PRESSURE RATING:	150 PSI (minimum)
	TYPE:	Grooved – See Note 3	
		FITTING STANDARD:	AWWA C606
		PRESSURE RATING:	150 PSI (minimum)
	TYPE:	Van Stone Flange	
		FITTING STANDARD:	Class 150 or Class 300 Van Stone type flanges with stainless steel stub ends, ASTM A240 Type 316L "as-welded grade",

GENERAL DESCRIPTION:	Large-Diameter Type 304L Stainless Steel Pipe		
SIZE:	2- through 30-inch nominal diameter		
			conforming to MSS SP 43, wall thickness same as pipe.
		PRESSURE RATING:	150 PSI (minimum)
FITTINGS – See Note 5			
	TYPE:	Flange	
		FITTING STANDARD:	Type: Forged stainless steel, ASTM A182, Grade F316, lap joint flange with stainless steel stub end, ASTM A240, Type 316L, welded grade conforming to MSS-SP43; schedule and size to match pipe. Faced and drilled ANSI Class 150, 1/16-inch raised face.
HARDWARE			
	See Note 8.		
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	See pipe schedule for color.		
	See Section 09 96 00 for coating requirements.		
NOTES			
1.	Pipe designated for vacuum service on the drawings shall be designed for and subject to full vacuum. Calculations showing that the selected wall thickness is acceptable for the service conditions shall be prepared and submitted. Minimum schedule 10S required.		
2.	Tees shall have no welds in the throat area and the crotch shall be reinforced with long radius design to eliminate sharp corners. Branch connections may include wrought tees or reducing tees, forged commercial welding branch fittings, extruded reducing branches, or weld-o-lets. Forged commercial welding branch fittings with butt welded outlet shall be stainless steel, in conformance with ASTM A182, Grade F316L, with schedule and material to match connected piping. No repair welding shall be performed on forged fittings without prior approval of the Engineer. Branches may be formed by an extrusion method (pulled) from pipe, where the extruded branch connections are less than 75 percent of the nominal diameter of the pipe. For extruded branch connections greater than 75 percent of the nominal diameter of the pipe, provide external reinforcing saddle strap if pipe working pressure is greater than 50 psi. Weld-o-lets may be used for connections up to 1/2-inch maximum. Construction shall match the connected pipe size, schedule, and FNPT outlet.		
3.	When used with Schedule 10S pipe, the groove shall be cut or rolled into a Schedule 40 spool piece to be welded to the pipe. The Schedule 40 spool piece		

GENERAL DESCRIPTION:	Large-Diameter Type 304L Stainless Steel Pipe
SIZE:	2- through 30-inch nominal diameter
	shall be taper bored at a 3:1 slope to provide a smooth transition of inside diameters. Machine grooves into pipe end (Schedule 40, minimum) in accordance with grooved fitting manufacturer's recommended dimensions, tolerances, and finishes. Roll cutting of grooves into piping will be permitted on minimum Schedule 40 pipe. The interior pipe wall shall be smooth and free of crevices, gouges, or other anomalies.
4.	Shop Fabricated Assemblies: • Shop fabricated assemblies shall be butt welded. • All welding shall be performed in the shop in accordance with the latest editions of Section IX of the ASME Boiler and Pressure Vessel Code and ASME Code for Pressure Piping, ASME B31.3 (normal service), as applicable. • All welds shall have 100 percent penetration. The internal weld bead shall be small, smooth and continuous with no crevices, pits or other voids. The external weld bead shall be well rounded, smooth and continuous with no anomalies. • All welded connections shall be parallel and perpendicular to the extent that the piping appears to be correct to the naked eye. • Procedure: o Pipe edges shall be prepared by machine cutting or shaping using an aluminum oxide blade. Beveled ends shall conform to the requirements of ANSI B16.9. o Clean weld joints and weld joint areas both before and after welding in accordance with ASTM A380 using stainless steel wire brushes or stainless steel wool. • Alignment: o Align ends to be joined within commercial tolerances on diameter, wall thickness, and out-of-roundness. o When joining pipes of different wall schedule, taper bore the interior of the larger schedule pipe to match the interior diameter of the connecting pipe with a maximum 1:3 slope. o Root opening at the joint shall be as stated in the procedure specification. • Welding: o The direct current, straight polarity, gas tungsten-arc (GTAW) process shall be used for all welding. Welding may be by manual GTAW or automatic (orbital) GTAW processes. o The inside of the pipe shall be purged with Argon gas during welding and while the weld is cooling to prevent oxidation of the weld. • Tack Welds: o All tack welds shall be made by a qualified welder. o All tack welds shall be made with welding rod the same as that used for the succeeding root pass. o Tack welds shall be small enough to be readily fused into the bead of the root pass.

GENERAL DESCRIPTION:	Large-Diameter Type 304L Stainless Steel Pipe
SIZE:	2- through 30-inch nominal diameter
	○ Thoroughly clean tack welds with a stainless steel wire brush prior to the root pass to prevent pinholing or excessive porosity. ○ Tack welds, which have cracked, shall be completely removed prior to making the root pass. ○ Surface defects, which will affect the soundness of the weld, shall be removed, visually inspected, and re-welded. ○ Where permitted, branch connections shall be fitted and groove-welded in accordance with the details described and shown in Chapter V of ASME B31.3.
5.	For connections requiring field assembly: • Welded: Field welding of stainless steel piping connections will not be allowed. ○ Van Stone Flanges: Flanges shall be provided preferentially for all pipe-to-pipe joints. ○ Threaded: For connections to weld-o-let outlet for instrument or sample taps only. ○ Union Fittings: Where noted or shown. ○ Flanged: For connections to flanged devices, or where otherwise noted or shown. ▪ Type: Forged stainless steel, ASTM A182, Grade F316, lap joint flange with stainless steel stub end, ASTM A240, Type 316L, welded grade conforming to MSS-SP43; schedule to match pipe. ▪ Dimensions: To match connected piping, faced and drilled ANSI Class 150, 1/16-inch raised face, unless otherwise shown or required for connection to equipment. ○ Groove Fittings: Where noted or shown. ▪ LIQUID SERVICE: • *Style: Segmented and bolted. Victaulic, Style 77; or equal* • Victaulic Style 232S restrained flexible coupling with EPDM gasket ▪ AIR SERVICE: • *Victaulic Style 232S restrained flexible coupling with silicone gaskets suitable for use with air and rated to 300°F.*
6.	CLEANING, DESCALING, PICKLING AND PASSIVATING • All stainless steel piping, fabrications, fittings and assemblies shall be shop fabricated and shall be cleaned, descaled, pickled and passivated per ASTM A380-06, ASTMA967-05 and Ferroxyl Inspected per ASTM A967-05. ○ Pickling: Process shall be by immersion method. Spray methods shall not be allowed. Fabrication size shall be constructed and coordinated with the Pickle/Passivation process such that the fabrications can be completely immersed. Contact time shall be minimum of four hours.

GENERAL DESCRIPTION:	Large-Diameter Type 304L Stainless Steel Pipe
SIZE:	2- through 30-inch nominal diameter
	○ Passivation: Rinsing must be done directly following pickling so solution does not dry. Rinsing shall use water with chloride content less than 25 mg/L. Contact with air to create passive film on the surface. Repeat pickling/passivation process if foreign material or scale has not been removed. ○ Inspection: Provide written certification that all parts have been cleaned, pickled and passivated per referenced standards. Provide Ferroxyl testing per referenced standards. ○ Shipping and Handling: Cap/seal all openings prior to shipment. Place items on clean wood surfaces and handle with non-ferrous metals for lifting and restraining during shipment. Materials shall be shipped in an enclosed trailer, and shall be stored indoors at all times.
7.	The Contractor shall provide additional non-welded joints as necessary to facilitate transportation of the pipe system components as well as construction. The Contractor is solely responsible for locating joints to avoid conflict with all other components of the Work. Contractor shall indicate all non-welded joints as part of the shop drawing submittal.
8.	Flanged Joints: Type 304 or 316 stainless steel. ASTM A193, Grade B8M hex head bolts and washers; Grade B8M hex head nuts, or equivalent. Coordinate bolt length to meet flange and device requirements. Grooved Joints: Type 316 stainless steel. Grade B-8M, Class 2; coupling manufacturer's standard size and shapes.

SST02

GENERAL DESCRIPTION:	Small-Diameter Type 304L Stainless Steel Pipe		
SIZE:	½- through 3-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	304L Stainless Steel	
	MATERIAL STANDARD:	ANSI B16.13 ASTM A312 ASTM A999	
	SCHEDULE OR SDR:	Schedule 40	
	PRESSURE RATING OR CLASS:	150 PSI	
PIPE JOINTS			
	TYPE:	Threaded	
		JOINT STANDARD:	NPT
		PRESSURE RATING:	150 PSI
GASKETS			
	See pipe schedule for gasket material selection.		
FITTINGS			
	MATERIAL:	304L Stainless Steel, SCH 40	
		MATERIAL STANDARD:	ANSI B16.13 ASTM A312 ASTM A999
	TYPE:	Threaded	
		FITTING STANDARD:	NPT ANSI/MSS SP-114, ASTM A351
		PRESSURE RATING:	150 PSI
HARDWARE			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	See pipe schedule for color.		
	See Section 09 96 00 for coating requirements.		
NOTES			

GALV01

GENERAL DESCRIPTION:	Galvanized Steel Pipe		
SIZE:	Less than or equal to 4-inch nominal diameter		
PIPING MATERIAL			
	MATERIAL:	Galvanized Steel	
	MATERIAL STANDARD:	ASTM A53, Type S, Grade B	
	SCHEDULE OR SDR:	Schedule 40	
	PRESSURE RATING OR CLASS:	150 PSI	
PIPE JOINTS			
	TYPE:	Threaded	
		JOINT STANDARD:	ANSI B16.3
		PRESSURE RATING:	150 PSI
	TYPE:	Flanged	
		JOINT STANDARD:	ANSI B16.1
		PRESSURE RATING:	150 PSI
GASKETS			
	See pipe schedule for gasket material selection.		
FITTINGS			
	MATERIAL:	Galvanized Malleable Iron, Class 150	
		MATERIAL STANDARD:	ANSI B16.3
	TYPE:	Flanged	
		FITTING STANDARD:	AWWA C207, Class D (hub style, slip-on) See Note 1
		PRESSURE RATING:	150 PSI
	TYPE:	Threaded	
		JOINT STANDARD:	ANSI B16.3
		PRESSURE RATING:	150 PSI
HARDWARE			
	See Paragraph 2.10 of this Specification Section.		
LINING			
	MATERIAL:	N/A	
		MATERIAL STANDARD:	N/A
COATING			
	See pipe schedule for color.		
	See Section 09 96 00 for coating requirements.		
NOTES			
1.	Flat faced or raised face to be compatible with connecting piping, ANSI B16.1 Standard.		

APPENDIX B

Gaskets

GASKETS

SBR			
	JOINT/FITTING TYPE:	Push-On, Mechanical, and Proprietary Joints	
		MATERIAL:	Vulcanized styrene butadiene rubber (SBR).
		STANDARD:	ANSI/AWWA C111/A21.11, unless otherwise noted.
	JOINT/FITTING TYPE:	Flanged – See Note 5	
		MATERIAL:	Full faced, ⅛-inch thick, red rubber (SBR), hardness 80 (Shore A), rated to 200° F
		STANDARD:	ANSI B16.21
EPDM			
	JOINT/FITTING TYPE:	Grooved, Flanged – See Note 5	
		MATERIAL:	Full faced, ⅛-inch thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 300° F
		STANDARD:	ANSI B16.21
	JOINT/FITTING TYPE:	Grooved	
		MATERIAL:	EPDM
		STANDARD:	ASTM D2000 and AWWA C606
HALOGENATED BUTYL			
	JOINT/FITTING TYPE:	Grooved	
		MATERIAL:	Halogenated butyl, Grade M
		STANDARD:	ASTM D2000 and AWWA C606
VITON (FKM)			
	JOINT/FITTING TYPE:	Flanged – See Note 5	
		MATERIAL:	Fluoroelastomer, hardness 75 (shore A) – See Note 6
		STANDARD:	ANSI B16.21
PTFE			
	JOINT/FITTING TYPE:	Flanged – See Note 5	
		MATERIAL:	Polytetrafluoroethylene
		STANDARD:	ANSI B16.21
NOTES			
1.	Gasket pressure rating to equal or exceed the system test pressure.		
2.	Blind flanges shall include a gasket which covers the entire inside face.		
3.	Gaskets shall be compatible with temperature, pressure, and service of the pipe.		
4.	Gaskets shall be the standard product of the pipe manufacturer. Alternate gaskets shall only be provided if deemed acceptable by the Engineer.		

NOTES	
5.	Flanged gaskets shall be the high performance type satisfying the special requirements of ANSI/AWWA C111/A21.11 Appendix C, Sec. C.2 and have at least three bulb type rings molded into both faces of the gasket.
6.	For use with air piping, gaskets shall be rated to 400°F and 150 psi, unless specifically noted otherwise.

APPENDIX C

Couplings

COUPLINGS

TYPE 1		
	GENERAL DESCRIPTION:	Straight and Transition, between dissimilar or the same pipe material, buried installations
	USE WITH:	Steel, C900 PVC, and Ductile Iron
	SIZE:	2”- 24” nominal diameter, see Note 1
	PRESSURE RATING:	260 PSI
	MATERIAL:	Ductile iron, ASTM A536
	LINING:	Fusion bonded epoxy coating, AWWA C213
	COATING:	Fusion bonded epoxy coating, AWWA C213
	GASKET:	SBR ASTM D2000 MBA 710 unless specifically noted otherwise
	PRODUCT:	Romac Industries Style 501 or approved equivalent
	NOTES:	1. If coupling is located within the minimum restrained length, or where specifically noted on the Plans, provide external restraint harness Romac Series 600 (12-inch and smaller for ductile iron, 14-inch and larger for C900 PVC) to provide longitudinal restraint with vertical joint flexibility. Thrust blocks shall only be provided where specifically shown on the plans or where deemed acceptable by the Engineer. 2. Minimum sleeve length shall be 5” for 2”-18” nominal pipe size and 7” for >18” nominal pipe size.
TYPE 2		
	GENERAL DESCRIPTION:	Straight, restrained, between the same pipe material, buried installations
	USE WITH:	Ductile iron, steel, and C900 PVC
	SIZE:	12”- 48” (ductile iron), 12” (steel), and 12”-24” (C900 PVC)
	PRESSURE RATING:	12”-16” ductile iron: 350 PSI 18”-24” ductile iron: 250 PSI 30”-48” ductile iron: 150 PSI PVC: 150 PSI
	MATERIAL:	Body: beveled, flared, or formed carbon steel, AWWA C219
	LINING:	Fusion bonded epoxy coating, AWWA C213
	COATING:	Fusion bonded epoxy coating, AWWA C213
	GASKET:	14-24”: standard MJ gasket per ANSI/AWWA C111/A21.11 12” and 30”-48”: SBR ASTM D2000
	PRODUCT:	Romac FC400RG, or approved equivalent

	NOTES:	1. Provide Romac RomaGrip or mechanical joint retainer glands as required by the manufacturer. 2. Provide 7/8-9 roll thread, ductile iron restraining bolts per ASTM A536. 3. Provide heat-treated ductile iron restraining lugs per ASTM A536. 4. Provide 304 stainless steel nuts and bolts.
TYPE 3		
	GENERAL DESCRIPTION:	Reducing Coupling, buried installations
	USE WITH:	C900 PVC, Steel, Ductile Iron connections with reduction in size/change in materials, unrestrained
	SIZE:	14”- 48”
	PRESSURE RATING:	150 PSI
	MATERIAL:	Beveled, flared, or formed carbon steel with minimum yield of 30,000 PSI
	LINING:	Fusion bonded epoxy coating, AWWA C213
	COATING:	Fusion bonded epoxy coating, AWWA C213
	GASKET:	Nitrile Butadiene Rubber (NBR), AWWA C219 and ASTM D20000
	PRODUCT:	Romac Industries Style RC400 or approved equivalent
	NOTES:	1. Provide trackhead bolts, heavy hex nuts, 5/8” UNC rolled thread, high strength, low alloy corrosion-resistant steel per AWWA C111. Threads shall be protected with plastic caps on each bolt end.
TYPE 4		
	GENERAL DESCRIPTION:	Field Flange Adapter, exposed installations
	USE WITH:	Ductile Iron and Steel Pipe tested in accordance with AWWA C600 or ASTM D2774 and conforming to ANSI/AWWA C151/A21.51
	SIZE:	3” – 12”
	PRESSURE RATING:	3”-8”: 250 PSI 10”-12”: 200 PSI
	MATERIAL:	Ductile Iron, ASTM A536 Flanges: ANSI/AWWA C110/A21.10
	LINING:	Manufacturer’s standard high build epoxy, MEGA-BOND by EBAA Iron Inc. or approved equivalent.
	COATING:	Manufacturer’s standard high build epoxy, MEGA-BOND by EBAA Iron Inc. or approved equivalent.
	GASKET:	EBAA E-Z Flange Gasket (ductile iron pipe); Transition gasket as required by the manufacturer (steel pipe)
	PRODUCT:	EBAA Iron, Inc. Series 1000 E-Z Flange, or approved equivalent

	NOTES:	1. For interior/exposed applications only. Not for use on buried applications.
TYPE 5		
	GENERAL DESCRIPTION:	Restrained Flange Adapter, buried installation
	USE WITH:	Ductile iron, C900 PVC, steel, and HDPE Ductile Iron and Steel Pipe tested in accordance with AWWA C600, AWWA C605, or ASTM D2774
	SIZE:	3”-24” (ductile iron and PVC) 3”-12” (steel and HDPE) 30”-48” (ductile iron)
	PRESSURE RATING:	3”-16” ductile iron: 350 PSI 18”-24” ductile iron: 200 PSI minimum 30”-48” ductile iron: 150 PSI 4”-20” DR18 C900 PVC: 235 PSI 24” DR18 C900 PVC: 150 PSI 4”-24” DR25 C900 PVC: 165 PSI 3”-12” steel: 350 PSI 3”-12” DR11 HDPE: 160 PSI
	MATERIAL:	Ductile Iron, ASTM A536 Flanges: ANSI/AWWA C111/A21.11 with flange surface facing in accordance with ANSI/AWWA C207. ANSI B16.5 Class 150/125 drilling pattern.
	LINING:	Wetted parts: fusion bonded epoxy per ANSI/AWWA C213 External parts: fusion bonded epoxy per ANSI/AWWA C116/A21.16 Restraint Ring: Manufacturer’s standard high build epoxy, MEGA-BOND by EBAA Iron Inc. or approved equivalent.
	COATING:	Manufacturer’s standard high build epoxy, MEGA-BOND by EBAA Iron Inc. or approved equivalent.
	GASKET:	Provide transition gaskets where required by the manufacturer.
	PRODUCT:	EBAA Iron, Inc. Series 2100 MEGAFLANGE, or approved equivalent.
	NOTES:	1. Provide stainless steel hardware. 2. For buried installation only. 3. Set screw type grips are not acceptable.
TYPE 6		
	GENERAL DESCRIPTION:	Flanged Dismantling Joint, buried installations
	USE WITH:	Ductile iron, steel, PVC
	SIZE:	3”-48”
	PRESSURE RATING:	3”-12”: 175 PSI 14”-48”: 150 PSI
	MATERIAL:	Flanged Spool: AWWA Class D ring flange, compatible with ANSI Class 125 or 150 bolt

		circles. SCH 40 ASTM A53 (3”-12”); ASTM A36 carbon steel (14”-48”) End Ring and Body: ductile iron ASTM A536 (3”-12”); carbon steel ASTM A36 with AWWA C207 Class D flanges. Hardware: 304 SST Tie Rods: 304 SST, ASTM A193 gr B8 or B8M
	LINING:	Fusion bonded epoxy coating
	COATING:	Fusion bonded epoxy coating
	GASKET:	Water/sewer Service: NBR ASTM D2000 MBA810Z Air Service: Provide EPDM peroxide cured gasket when used with aeration piping (ALP or AHP). Gasket shall be suitable for use with temperatures up to 250°F.
	PRODUCT:	Romac Industries, Inc. Style DJ400 or approved equivalent
	NOTES:	N/A
TYPE 7		
	GENERAL DESCRIPTION:	Stainless Steel Pipe Couplings, interior/exposed installations
	USE WITH:	Steel, stainless steel
	SIZE:	3”-48”
	PRESSURE RATING:	Pressure rating shall be 1.5 times working pressure, unless specifically noted otherwise.
	MATERIAL:	316 SST or Carbon Steel, see Note 3
	LINING:	Fusion bonded epoxy (for carbon steel)
	COATING:	Fusion bonded epoxy (for carbon steel)
	GASKET:	Match pipe system gasket selection
	PRODUCT:	AWWA C227 Straub Flex Coupling or approved equivalent
	NOTES:	1. Coupling shall meet all applicable AWWA and NSF requirements. 2. Provide Romac AWWA M-11 harness restraint system, or approved equivalent, where external restraint or anchoring is not otherwise provided. 3. Galvanized components are not acceptable. 4. Provide stiffening ring as required by the manufacturer.
TYPE 8		
	GENERAL DESCRIPTION:	Mechanical Joint Adaptor, buried installations
	USE WITH:	Ductile iron pipe direct connections between MJ fittings and valves
	SIZE:	3”-36”

	PRESSURE RATING:	350 PSI (3”-24”) 250 PSI (30”-36”)
	MATERIAL:	Ductile Iron
	LINING:	Protecto 401 Epoxy
	COATING:	Epoxy
	GASKET:	N/A
	PRODUCT:	Foster Adaptor
	NOTES:	1. Provide stainless steel hardware

FLEXIBLE COUPLINGS

Type 20		
	GENERAL DESCRIPTION:	Single Sphere Flexible Coupling, interior/exposed installations
	USE WITH:	Flanged wastewater service pipe systems to accommodate axial compression and extension, lateral deflection, angular movement, and vibration
	SIZE:	4”-30”
	PRESSURE RATING:	See Note 1
	TEMPERATURE RATING:	265°F
	MATERIAL:	Elastomer (cover and tube): EPDM Flanges: 304 SST, freely rotating on the bellows
	LINING:	N/A
	COATING:	N/A
	GASKET:	N/A
	PRODUCT:	Proco Style 240 single sphere, or approved equivalent
	NOTES:	1. Pressure rating at the anticipated operating temperature shall be equivalent to the test pressure for the associated pipe system. Reference the Pipe Schedule for additional information. 2. Provide external limit/control rods to limit fitting expansion and contraction. 3. Rods and hardware shall be SST. 4. Couplings shall be installed within manufacturer's recommended piping misalignment limits. Expansion couplings shall not be used to correct pipe misalignment. 5. Pipe systems shall be fully supported either

		side of the flexible coupling. 6. Do not position against check or isolation valves.
Type 21		
	GENERAL DESCRIPTION:	Bellows Connector Expansion Joint, interior/exposed installations
	USE WITH:	For use with digester gas piping
	SIZE:	2”-12”
	PRESSURE RATING:	225 PSI at 150°F 110 PSI at 480°F
	TEMPERATURE RATING:	480°F
	MATERIAL:	All wetted parts: Stainless Steel Vanstone Flange: Carbon Steel ANSI 150#
	LINING:	N/A
	COATING:	N/A
	GASKET:	Neoprene Grommet
	PRODUCT:	Flexicraft Industries, Bellows Connector Expansion Joint, or approved equivalent
	NOTES:	1. Joints are to be provided with stainless steel drop-in liners and carbon steel covers. 2. Tie rods shall be included to prevent overextension of the expansion joints from pressure thrust loads. The number and size of the control rods shall be sufficient for the maximum system test pressure.
Type 22		
	GENERAL DESCRIPTION:	Reducing Expansion Joints, interior/exposed installations. See Note 1
	USE WITH:	Flanged wastewater service pipe systems to accommodate axial compression and extension, lateral deflection, angular movement, and vibration
	SIZE:	2”x1” to 18”x16”
	PRESSURE RATING:	See Note 2
	TEMPERATURE RATING:	250°F

	MATERIAL:	Elastomer (cover and tube): EPDM
	LINING:	N/A
	COATING:	N/A
	GASKET:	N/A
	PRODUCT:	Proco Style RE-231 (eccentric single wide-arch expansion joint), Proco Style RC-231 (concentric singe wide-arch expansion joint), or approved equal
	NOTES:	1. Provide eccentric or concentric expansion joint as denoted on the Plans. 2. Pressure rating at the anticipated operating temperature shall be equivalent to the test pressure for the associated pipe system. Reference the Pipe Schedule for additional information. 3. Provide external limit/control rods to limit fitting expansion and contraction. 4. Rods and hardware shall be SST. 5. Couplings shall be installed within manufacturer's recommended piping misalignment limits. 6. Pipe systems shall be fully supported either side of the flexible coupling. 7. Do not position against check or isolation valves.
Type 23		
	GENERAL DESCRIPTION:	Chemical Service Flexible Coupling, interior/exposed installations
	USE WITH:	Chemical service, PVC pipe system applications
	SIZE:	1.5"-36"
	PRESSURE RATING:	1.5"-6": 225 PSI 8"-12": 210 PSI 14"-20": 150 PSI 24"-36": 100 PSI (minimum)

	TEMPERATURE RATING:	250°F
	MATERIAL:	Cover: EPDM
	LINING:	PTFE
	COATING:	N/A
	GASKET:	N/A
	PRODUCT:	Proco Series 231/ET PTFE expansion joint, or approved equal
	NOTES:	1. Provide external limit/control rods to limit fitting expansion and contraction. 2. Rods and hardware shall be SST. 3. Couplings shall be installed within manufacturer's recommended piping misalignment limits. Expansion couplings shall not be used to correct pipe misalignment. 4. Pipe systems shall be fully supported either side of the flexible coupling. 5. Do not position against check or isolation valves.

QUICK CONNECT COUPLINGS

Type 40		
	GENERAL DESCRIPTION:	Twin cam arm actuated, male and female, locking
	USE WITH:	Chemical Systems
	SIZE:	½”-4”
	PRESSURE RATING:	See Note 1
	TEMPERATURE RATING:	200°F
	MATERIAL:	Glass-filled polypropylene or PVDF with EPDM
	LINING:	N/A
	COATING:	N/A
	GASKET:	Viton-A or Teflon gaskets as recommended for the chemical service by the manufacturer
	PRODUCT:	BANJO, Qianli, or approved equivalent
	NOTES:	1. Pressure rating at the anticipated operating temperature shall be equivalent to the test pressure for the associated pipe system. Reference the Pipe Schedule for additional information. 2. End Connections: NPT threaded or flanged to match piping connections. Hose shank for chemical installations. 3. Plugs and Caps: Female dust cap for each male end; male dust plug for each female end.
Type 41		
	GENERAL DESCRIPTION:	Twin cam arm actuated, male and female, locking
	USE WITH:	Sewage service
	SIZE:	½”-4”
	PRESSURE RATING:	150 PSI (minimum)
	TEMPERATURE RATING:	380°F (maximum)
	MATERIAL:	Stainless steel
	LINING:	N/A
	COATING:	N/A
	GASKET:	Buna N gaskets as recommended for the service by the manufacturer.

	PRODUCT:	OPW Kamlok or approved equal
	NOTES:	1. End Connections: NPT threaded or flanged to match piping connections. Hose shank quick connect coupler. 2. Plugs and Caps: Female dust cap for each male end; male dust plug for each female end.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 40 61 13 – PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. General requirements which apply to all Instrumentation and Control for Process Systems (hereafter referred to as I&C).

B. Related Sections

1. The Contract Documents are a single integrated document. As such, all Divisions and Sections are applicable. The Contractor and its Subcontractors are responsible to review all parts of the Contract Documents to provide a complete and coordinated project.

C. Complete I&C System

1. The requirements for the I&C System shall be the responsibility of a single company hereafter referred to as the Instrumentation Supplier (IS). The IS shall be responsible for all parts of this Section and Sub-Sections as well as all other related sections that may pertain to the I&C System.
2. The Contractor, through the IS and qualified electrical and mechanical installers, shall be responsible to the Owner for the implementation of a complete I&C System. The IS shall provide all necessary coordination, material, and labor such that the entire system be complete and functional. This includes but is not limited to the proper operation and monitoring of electrical power systems, process systems, mechanical equipment, instrumentation, control panels, programmable controllers, communications/networking, and SCADA system.
3. The overall I&C system design is based upon non-certified information that has been furnished by various equipment manufacturers and vendors. It is the Contractor's responsibility to include in the bid and installation all labor and material to provide a complete system based upon actual information from equipment being supplied for the project. Any changes or additions due to non-certified manufacturer or vendor information shall be provided at no additional cost to the Owner.

1.2 REFERENCES

A. The installation and commissioning of the I&C System shall conform to all applicable codes, regulations, standards, and specifications, including, but not limited to those listed below. These publications are referenced to by designation but not by edition. The latest edition accepted by the Authority Having Jurisdiction in effect at the time of bid shall govern.

1. State and Local Codes and Authority Having Jurisdiction (AHJ)

2. American National Standards Institute (ANSI)
3. American Petroleum Institute (API)
4. Federal Communications Commission (FCC)
5. Federal Occupational Safety and Health Act (OSHA)
6. International Society of Automation (ISA)
7. Institute of Electrical and Electronic Engineers (IEEE)
8. National Electric Code (NEC).
9. National Electrical Manufacturers Association (NEMA)
10. National Fire Protection Association (NFPA)
11. Underwriters Laboratories, Inc. (UL)

1.3 DEFINITIONS

A. The following definitions may be used throughout this section and subsections (refer to the contract drawings sheet GI-1 for instrumentation abbreviations):

1. CTC: Communications termination cabinet.
2. FAT: Factory acceptance test.
3. HMI: Human machine interface.
4. I&C: Instrumentation and control for process systems
5. IS: Instrumentation supplier.
6. LAN: Local area network.
7. LCP: Local control panel.
8. NC: Normally closed.
9. NO: Normally open.
10. OIT: Operator interface terminal.
11. OSI: Owner's System Integrator.
12. PC: Personal computer.
13. PID: Control action, proportional plus integral plus derivative.
14. PLC: Programmable logic controller.
15. P&ID: Process and instrumentation diagram
16. RIO: Remote input/output
17. SCADA: Supervisory control and data acquisition.
18. SI: System Integrator.
19. UPS: Uninterruptible power supply.
20. VCP: Vendor control panel.
21. WAN: Wide area network

1.4 I&C SYSTEM REQUIREMENTS

A. Work provided outside of Contractor's scope:
   1. The following equipment is being furnished by the Owner:
      a. SCADA Equipment

B. The Work is to provide a complete and operational I&C System as described by the Contract Documents. This includes but is not limited to the following:

1. Before providing a bid as the IS, coordinate with all bidders such that all costs associated with a complete I&C System are accounted for. The Owner shall not be responsible for any additional costs for scope items that have been excluded from the bid because of not coordinating with all bidders.

2. The IS shall submit a statement of qualifications verifying that it meets the requirements of 406113.1.8. The IS must be approved by the Engineer before proceeding with the Work.

3. In order to provide a complete system, oversee and coordinate with all equipment and services being provided outside of Contractor's scope.
    a. The Engineer is responsible to ensure that equipment being supplied by others related to the I&C System complies with the requirements of the Contract Documents
    b. The Contractor and IS are responsible to coordinate the installation, commissioning and scheduling of equipment related to the I&C System that are provided by others.

4. Oversee and coordinate with all equipment and services being provided by the Contractor but outside of the IS's scope.
    a. Inform all vendors and suppliers providing equipment related to the I&C System the requirements of Division 40.
    b. The Owner is not responsible for any additional costs incurred by requiring vendors and/or subcontractors to meet the requirements of Division 40.
    c. If a vendor or supplier is unable to meet the requirements of Division 40, the Contractor may submit in writing to the Engineer the reasons for non-compliance. The Engineer will then evaluate the reasons and determine whether a solution may be determined or if a different vendor or supplier is required.
    d. The Contractor and IS are responsible for coordinating with vendors and suppliers the FAT, installation, commissioning, calibration, and scheduling for the associated I&C equipment.
    e. The IS is responsible to ensure that panel and loop drawings be supplied for vendor and subcontractor equipment. If the vendors and/or subcontractors are preparing the panel and/or loop drawings, they shall comply with the requirements of Division 40 and shall match those provided by the IS.

5. The IS shall conduct a Pre-Submittal Conference before producing any submittals. The conference should include all parties involved with the I&C System including the Engineer and Owner. The purpose of the conference shall be to review the project, make sure all parties understand their roles and responsibilities and to go over submittal requirements.

6. Prepare I&C System Submittals which includes the following:
    a. Instrumentation hardware submittal (including TR20 forms).
    b. Recommended spare parts submittal.

7. Following submittal approvals, do the following:
    a. Procure all instrumentation hardware and accessories.
    b. Procure hardware for and fabricate all control panels being provided.

c. Perform FAT's for all control panels being provided.

8. Programming and integration shall be supplied by the OSI. Oversee and coordinate the programming and integration with the OSI for a complete I&C System.

9. Oversee the installation of the I&C System.

10. Perform bench and field calibrations of instruments as required.

11. Oversee and document loop testing.

12. Oversee and document commissioning.

13. Maintain record drawings.
    a. Maintain on the construction site a set of the Instrumentation Drawings that shall be continuously marked up during construction.
    b. The drawings should be updated at least weekly and will be checked monthly by the Owner's representative.
    c. Upon completion of startup, submit the marked-up drawings to the Engineer for review and for drafting.

14. Prepare O&M manuals.
    a. Provide O&M manuals in accordance with Section 017823.
    b. Prepare an O&M manual for each major process area or building. Each of these manuals shall be divided into the following categories:
        1) Table of Contents/Index.
        2) Process & Instrumentation Diagrams
        3) Control Panel Record Drawings, Bill of Materials and Design Data.
        4) Record Loop Drawings
    c. Prepare O&M manuals that cover comprehensive information for the I&C System. These manuals shall include the following:
        1) Table of Contents/Index.
        2) Finalized Instrument Summary
        3) Finalized TR20 Instrument Forms
        4) Instrumentation Installation Details
        5) Instrument Operational Manuals
        6) Recommended Spare Parts List

15. Provide training.

1.5 ACTION SUBMITTALS

A. General
    1. Submittals for Division 40 shall meet the requirements of Section 013300 Contractor Submittals. In addition, the following requirements shall be met:
        a. Submittals shall include bills of materials with quantities, makes, models, exact part numbers and descriptions.

b. Edit all submittals such that only pertinent information is submitted. Neatly cross out information that does not apply, options that are not being supplied, etc.
c. Show product dimensions, construction, and installation details, wiring diagrams, and specifications.
d. If there are exceptions to the Contract Drawings and Specifications, provide a list of exceptions with detailed explanations for the exceptions. The Engineer will review the list of exceptions and determine whether a solution may be determined or if the exception(s) will not be allowed.

2. Furnish submittal required by each Section within Division 40.
3. When submitting on equipment, use the equipment and instrumentation tags depicted in the Contract Drawings.

B. Instrumentation hardware submittal

1. Provide a comprehensive submittal that includes all instrumentation being supplied by the IS. Divide the submittal into the following:
   a. Table of Contents/Index.
   b. Instrument summary.
   c. Instrument TR20 Forms.
   d. Instrument Cut Sheets.
   e. Instrument Installation Drawings.
2. Provide an instrument summary (sorted by tag number) that has the following information:
   a. Tag number.
   b. Make, model and description.
   c. Associated process.
   d. Location.
   e. Calibrated range.
   f. Referenced loop drawing number and P&ID.
   g. Associated PLC.
3. Furnish TR20 instrumentation forms for each instrument using the forms outlined in ISA-TR20.00.01-2007. This requirement includes all instruments that are being installed as part of the project, whether they are Contractor, Owner and/or Vendor supplied. Show on each sheet who is the responsible party for supplying the instrument. The TR20 sheets should be provided electronically in Microsoft Word or Excel as well.
4. Provide instrument cut sheets for each instrument make and model being supplied for the project. Each cut sheet should have a list of instrument tag numbers that pertain to that cut sheet. The cut sheets should have enough information to verify that the instrument conforms to the Contract Drawings and Specifications.
5. Instrument installation drawings
   a. Provide instrument installation drawings for each make and model of instrument being supplied.
   b. Delineate what is being supplied by the IS and what is being supplied by other installers.
   c. Show overall dimensions, mounting locations and elevations.
   d. Show all cabling, conduit and piping locations.
   e. Show the ambient conditions of the location where the instrument is being installed which includes ambient temperature and humidity extremes, whether the atmosphere is corrosive and the area classification.

f. Show mounting requirements, brackets, stands and anchoring.
g. Show means for sun protection where required.

C. Recommended Spare Parts Submittal
1. Submit a list of spare parts for all the equipment associated with the I&C System. The list of spare parts shall include list pricing for each item.
2. Provide the name, address and phone number for each manufacturer and manufacturer's local sales representative.
3. Indicate whether the spare parts are being provided under this contract or not.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

B. Calibration certificates.

C. As-built TR20 forms.

1.7 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.8 QUALITY ASSURANCE

A. All equipment supplied for this project shall meet the requirements of the National Electric Code (NEC) and shall be listed by and bearing the label of the Underwriters' Laboratories (UL).

B. The IS shall be a company that has been actively involved in the installation and commissioning of I&C Systems for a minimum period of five years.

C. The IS shall have adequate facilities, manpower and technical expertise to perform the Work associated with the I&C System and as outlined by the Contract Documents.

D. The IS shall have similar project experience of at least four successfully completed projects for a similar wastewater system. The IS company must have performed similar work for these projects as required herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials provided under this Contract shall be new and free from defects.

2.2 MANUFACTURERS

A. All equipment provided for the I&C System shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

B. Instruments which utilize a common measurement principle (for example, float switches) shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

2.3 OPERATING CONDITIONS

A. The I&C System shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:
   1. Environment: Wastewater Treatment Plant.
   2. Temperature Extremes: -4°F to 104°F (Outdoors); 40°F to 104°F (Indoors).
   3. Relative Humidity: 20% to 90%, non-condensing.

B. Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided to maintain instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The Contractor shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. Instrumentation in hazardous areas shall be suitable for use in the hazardous or classified location in which it is to be installed.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

B. Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation,

shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the Engineer. If such tests reveal defects, the equipment shall be replaced.

3.2 MANUFACTURER'S SERVICES

A. Manufacturer's services shall be furnished for the following equipment:
   1. Vendor supplied equipment that contain programmable controllers, operator interfaces and/or instrumentation that requires site calibration.

B. The Contractor shall furnish the following manufacturer's services for the instrumentation listed below:
   1. Perform bench calibration.
   2. Oversee installation.
   3. Verify installation of installed instruments.
   4. Certify installation and reconfirm manufacturer's accuracy statement.
   5. Oversee loop testing and pre-commissioning
   6. Train the Owner's personnel.

3.3 INSTALLATION

A. Instrumentation shall be installed per the Instrument Installation Drawings that have been submitted and approved and per the requirements of Division 40. This includes all instrumentation for the I&C System, regardless of who the supplier is. Instrumentation shall be mounted so that it is easily accessible and viewable and such that it does not restrict access to other equipment. Mount instrumentation to pipe stands or wall mounts if they are not directly mounted or if the Contract Drawings indicate otherwise.

B. The I&C System indicated throughout the design are diagrammatic and therefore locations of equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the Owner exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the Contractor shall make such changes without additional cost to the Owner.

C. The I&C System is integrally connected to electrical, mechanical, and structural systems. Coordinate with these other disciplines the installation of these related components. All conduit, cables and field wiring shall be as required by Division 26.

D. Instruments, control panels and all other I&C System related equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

E. Each existing instrument to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The Contractor shall provide certification of this Work prior to reinstallation of each instrument.

F. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation system. The Contractor shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the Engineer for approval prior to commencing that Work. Such changes shall not be a basis of claims for extra Work or delay.

G. Instrumentation, control panels, wiring and all other I&C equipment shall be properly tagged and/or labeled per the requirements of Section 260553.

H. Installation of the I&C System shall be according to the finalized Loop Drawings

3.4 FACTORY ACCEPTANCE TESTING (FAT)

A. The IS shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the Engineer and Owner to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, and other pertinent systems and devices. A minimum of 10 days notification shall be furnished to the Engineer prior to testing. No shipments shall be made without the Engineer's approval.

B. For each FAT, the IS shall develop and submit a FAT Plan and Procedure Document within 10 days of the FAT. The FAT Plan and Procedure shall as a minimum shall have the following:
   1. Descriptions of test methods to be performed during the FAT.
   2. FAT Schedule and Procedure
   3. FAT Checklists that allow for sign-off and comments for each test method and procedure.

C. Control Panel Completion Test Methods: The following test methods should be performed during the FAT for each control panel:
   1. Completed Shop Drawings: Demonstrate that the control panel has been built according to the shop drawings and that the shop drawings are accurate.
   2. Panel Layout: Demonstrate that the control panel has been laid out as designed and as required by Division 40.
   3. Power Distribution: Demonstrate all power distribution circuits, including but not limited to AC power circuits, UPS operation, signals and circuits and DC circuits.
   4. Control Circuits: Demonstrate the correct installation of each control circuit. Using a signal generator or multi-meter, show the correct operation of each input, output, relay, barrier, buttons, switches, or any other control device. Demonstrate the proper functionality of any hard-wired interlocks that may be associated with each control circuit.

5. Panel Networking/Communications: If any form of communications is associated with the control panel, verify the proper operation of each communication port and link.

D. Control Loop Test Methods: To demonstrate that the control panel will provide its function as intended, provide the following control loop test methods. If programming for the control panel is provided by others, coordinate with the programmer to have all programming completed and tested prior to the FAT. If needed, coordinate to have the programmer present for the FAT.
   1. Alarm Functions: Verify and/or simulate each alarm condition associated with each control loop.
   2. Local Manual and Auto Functions: Verify and/or simulate each Local Manual and/or Auto function associated with each control loop.
   3. SCADA Manual and Auto Functions: Verify and/or simulate each SCADA Manual and/or Auto function associated with each control loop.
   4. Control Loop Interlocks: Demonstrate the functionality of any software interlocks that may be associated with each control loop.

E. If the FAT does not pass and needs to be repeated, the IS shall be responsible for additional per diem costs incurred by the Engineer and Owner.

F. All changes and/or corrections made during the FAT shall be noted on the checklists.

G. Following completion and approval of all FAT, provide the finalized checklists to the Engineer and as part of the equipment shop drawings.

3.5 FIELD QUALITY CONTROL

A. Allow for inspections by the Engineer and/or Owner of the I&C System at any time during the construction. Inspections shall be conducted to verify that the installation is per the requirements of the Contract Documents.

3.6 CALIBRATION

A. Devices provided under Division 40 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations need adjustment. Such adjustments, if required, shall be made only after consultation with the Engineer.

D. Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. For each instrument calibration, provide a calibration sheet and update the corresponding TR20 Instrument Form with the new calibration data. The Calibration sheet shall include the following as a minimum:
   1. Date of calibration
   2. Project Name.
   3. Tag Number.
   4. Manufacturer, model and serial number.
   5. Calibration data including range, input, output and measurement at each calibration point.
   6. Space for comments.
   7. Space for sign-off by party performing calibration.

G. A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the Engineer. The IS shall sign the tag when calibration is complete. The Engineer will sign the tag when the calibration and testing has been accepted.

3.7 LOOP TESTING

A. Each control loop shall have been installed according to the finalized loop drawing. Prior to the commencement of loop testing, the following pre-requisites should have been met:
   1. All associated equipment, conduit and wire has been permanently installed, terminated, and inspected.
   2. All wiring has been properly pulled, terminated, and labeled.
   3. Each wire has been tested with a point-to-point test.
   4. All control panels and electrical equipment have been checked out and tested as required by Division 26.
   5. All instrumentation has been appropriately installed and calibrated.
   6. Loop Test Forms for each loop to be tested have been created and will be available during the loop testing.

B. Each loop test shall have a Loop Test Form prepared and ready prior to each loop test. The loop test form shall have the following:
   1. Loop Number and Description
   2. Check-Off List with room for sign-off and dated by the IS, Programmer, and Owner's Witness as well as room for comments. The list of items to be checked off for each loop should include but is not limited to the following:
      a. Each power distribution circuit.
      b. Each control circuit.
      c. Each alarm circuit.
      d. Each PLC input/output point.
      e. Each Local Manual, Local Auto, SCADA Manual & SCADA Auto function.
      f. Each hard-wired and software interlock.

C. Upon completion of the above pre-requisites for loop testing, the IS shall oversee and coordinate each loop test. The IS is responsible to be present for all loop testing, whether the equipment was supplied by the IS or not. The IS is responsible to have all responsible parties associated with each loop present. This includes but is not limited to manufacturer representatives, vendor technicians, electrical installers, mechanical installers, and programmer. The IS shall coordinate with the Owner and Engineer to allow for witnessing of loop testing as deemed necessary by the Owner and Engineer.

D. Issues that arise during loop testing should be addressed and fixed immediately. If it is not feasible to immediately fix the issues, the loop testing should be re-scheduled as soon as possible to avoid delays. Any costs associated with re-testing and requiring all parties to return to the site shall in no way be incurred to the Owner.

E. Following a successful loop test, the appropriate parties should sign and date the Loop Test Forms. All Forms shall be certified and submitted to the Engineer as part of the O&M Manuals.

F. Following loop testing, in no way should any parts of the loop be modified. In no way shall any wiring be re-routed or re-terminated. If any such work occurs, all affected loops shall be re-tested at no expense to the Owner.

3.8 COMMISSIONING

A. The IS shall oversee, coordinate and be present during all commissioning activities. The IS shall be responsible for obtaining the assistance of the Contractor and Subcontractors as may be required for commissioning activities.

B. Commissioning shall commence after acceptance of wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Pre-commissioning shall demonstrate proper operation of every system with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

C. Commissioning and test activities shall follow detailed test procedures and check lists accepted by the Engineer. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the Engineer, which include calculated tolerance limits for each step. Completion of system commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the Engineer with a clear and unequivocal statement that system commissioning and test requirements have been satisfied.

D. Where feasible, system commissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the

control of field mounted automatic analog controllers or software-based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of field mounted, and software-based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

E. Electronic control stations incorporating proportional, integral, or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

3.9 TRAINING

A. Develop a Training Plan for the training requirements of Division 40 and submit it to the Engineer for approval. Coordinate with the Engineer and Owner the time and locations of each training session. Schedule the trainings for after the equipment has been pre-commissioned.

B. As part of the Training Plan, submit a résumé for everyone to be providing training. Training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

C. Each training session shall include a written agenda.

D. The Contractor shall train the Owner's personnel on the maintenance, calibration and repair of instruments provided.

E. Within 10 days after the completion of each session, the Contractor shall submit the following:
   1. A list of Owner personnel who attended the training.
   2. A copy of the training materials used during the session with notes, diagrams, and comments.

END OF SECTION 40 61 13

SECTION 40 61 21 – PROCESS CONTROL SYSTEM TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes in-factory and field-testing requirements.

B. Related Sections

1. The Contract Documents are a single integrated document. As such, all Divisions and Sections are applicable. The Contractor and its Subcontractors are responsible to review all parts of the Contract Documents to provide a complete and coordinated project.

C. Complete I&C System

1. The requirements for the I&C System shall be the responsibility of a single company hereafter referred to as the Instrumentation Supplier (IS). The IS shall be responsible for all parts of this Section and Sub-Sections as well as all other related sections that may pertain to the I&C System.
2. The Contractor, through the IS and qualified electrical and mechanical installers, shall be responsible to the Owner for the implementation of a complete I&C System. The IS shall provide all necessary coordination, material, and labor such that the entire system be complete and functional. This includes but is not limited to the proper operation and monitoring of electrical power systems, process systems, mechanical equipment, instrumentation, control panels, programmable controllers, communications/networking, and SCADA system.
3. The overall I&C system design is based upon non-certified information that has been furnished by various equipment manufacturers and vendors. It is the Contractor's responsibility to include in the bid and installation all labor and material to provide a complete system based upon actual information from equipment being supplied for the project. Any changes or additions due to non-certified manufacturer or vendor information shall be provided at no additional cost to the Owner.

1.2 SUBMITTALS

A. In addition to the submittal requirements of Section 40 61 13, provide the following:

1. Test Results:
   a. Pass/fail status of all digital I/O.
   b. Results of analog I/O testing.
2. Miscellaneous:

a. Detailed step-by-step in-factory and field test procedure at least 6 weeks in advance of scheduled test date. Include sign-off sheets and punch list forms and description of configurations to be tested.
b. Complete inventory of equipment to be tested at factory including make, model, and serial number. Label each piece of equipment.
c. Preventative maintenance schedule.

3. Submit in accordance with 01 33 00.

PART 2 - SERVICES

2.1 MANUFACTURER'S SERVICES

A. Manufacturer's services shall be furnished for the following equipment:
1. Vendor supplied equipment that contain programmable controllers, operator interfaces and/or instrumentation that requires site calibration.
2. Dissolved Oxygen Analyzers
3. Turbidity Analyzers

B. The Contractor shall furnish the following manufacturer's services for the instrumentation listed below:
1. Perform bench calibration.
2. Oversee installation.
3. Verify installation of installed instruments.
4. Certify installation and reconfirm manufacturer's accuracy statement.
5. Oversee loop testing and pre-commissioning
6. Train the Owner's personnel.

2.2 FACTORY ACCEPTANCE TESTING (FAT)

A. The IS shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the Engineer and Owner to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, and other pertinent systems and devices. A minimum of 10 days notification shall be furnished to the Engineer prior to testing. No shipments shall be made without the Engineer's approval.

B. For each FAT, the IS shall develop and submit a FAT Plan and Procedure Document within 10 days of the FAT. The FAT Plan and Procedure shall as a minimum shall have the following:
1. Descriptions of test methods to be performed during the FAT.
2. FAT Schedule and Procedure
3. FAT Checklists that allow for sign-off and comments for each test method and procedure.

C. Control Panel Completion Test Methods: The following test methods should be performed during the FAT for each control panel:
1. Completed Shop Drawings: Demonstrate that the control panel has been built according to the shop drawings and that the shop drawings are accurate.

2. Panel Layout: Demonstrate that the control panel has been laid out as designed and as required by Division 40.
3. Power Distribution: Demonstrate all power distribution circuits, including but not limited to AC power circuits, UPS operation, signals and circuits and DC circuits.
4. Control Circuits: Demonstrate the correct installation of each control circuit. Using a signal generator or multi-meter, show the correct operation of each input, output, relay, barrier, buttons, switches, or any other control device. Demonstrate the proper functionality of any hard-wired interlocks that may be associated with each control circuit.
5. Panel Networking/Communications: If any form of communications is associated with the control panel, verify the proper operation of each communication port and link.

D. Control Loop Test Methods: To demonstrate that the control panel will provide its function as intended, provide the following control loop test methods. If programming for the control panel is provided by others, coordinate with the programmer to have all programming completed and tested prior to the FAT. If needed, coordinate to have the programmer present for the FAT.
1. Alarm Functions: Verify and/or simulate each alarm condition associated with each control loop.
2. Local Manual and Auto Functions: Verify and/or simulate each Local Manual and/or Auto function associated with each control loop.
3. SCADA Manual and Auto Functions: Verify and/or simulate each SCADA Manual and/or Auto function associated with each control loop.
4. Control Loop Interlocks: Demonstrate the functionality of any software interlocks that may be associated with each control loop.

E. If the FAT does not pass and needs to be repeated, the IS shall be responsible for additional per diem costs incurred by the Engineer and Owner.

F. All changes and/or corrections made during the FAT shall be noted on the checklists.

G. Following completion and approval of all FAT, provide the finalized checklists to the Engineer and as part of the equipment shop drawings.

2.3 FIELD QUALITY CONTROL

A. Allow for inspections by the Engineer and/or Owner of the I&C System at any time during the construction. Inspections shall be conducted to verify that the installation is per the requirements of the Contract Documents.

2.4 CALIBRATION

A. Devices provided under Division 40 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations need adjustment. Such adjustments, if required, shall be made only after consultation with the Engineer.

D. Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. For each instrument calibration, provide a calibration sheet and update the corresponding TR20 Instrument Form with the new calibration data. The Calibration sheet shall include the following as a minimum:
   1. Date of calibration
   2. Project Name.
   3. Tag Number.
   4. Manufacturer, model, and serial number.
   5. Calibration data including range, input, output, and measurement at each calibration point.
   6. Space for comments.
   7. Space for sign-off by party performing calibration.

G. A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the Engineer. The IS shall sign the tag when calibration is complete. The Engineer will sign the tag when the calibration and testing has been accepted.

2.5 LOOP TESTING

A. Each control loop shall have been installed according to the finalized loop drawing. Prior to the commencement of loop testing, the following pre-requisites should have been met:
   1. All associated equipment, conduit and wire has been permanently installed, terminated and inspected.
   2. All wiring has been properly pulled, terminated and labeled.
   3. Each wire has been tested with a point-to-point test.
   4. All control panels and electrical equipment have been checked out and tested as required by Division 26.
   5. All instrumentation has been appropriately installed and calibrated.
   6. Loop Test Forms for each loop to be tested have been created and will be available during the loop testing.

B. Each loop test shall have a Loop Test Form prepared and ready prior to each loop test. The loop test form shall have the following:
   1. Loop Number and Description

2. Check-Off List with room for sign-off and dated by the IS, Programmer, and Owner's Witness as well as room for comments. The list of items to be checked off for each loop should include but is not limited to the following:
    a. Each power distribution circuit.
    b. Each control circuit.
    c. Each alarm circuit.
    d. Each PLC input/output point.
    e. Each Local Manual, Local Auto, SCADA Manual & SCADA Auto function.
    f. Each hard-wired and software interlock.

C. Upon completion of the above pre-requisites for loop testing, the IS shall oversee and coordinate each loop test. The IS is responsible to be present for all loop testing, whether the equipment was supplied by the IS or not. The IS is responsible to have all responsible parties associated with each loop present. This includes but is not limited to manufacturer representatives, vendor technicians, electrical installers, mechanical installers, and programmer. The IS shall coordinate with the Owner and Engineer to allow for witnessing of loop testing as deemed necessary by the Owner and Engineer.

D. Issues that arise during loop testing should be addressed and fixed immediately. If it is not feasible to immediately fix the issues, the loop testing should be re-scheduled as soon as possible to avoid delays. Any costs associated with re-testing and requiring all parties to return to the site shall in no way be incurred to the Owner.

E. Following a successful loop test, the appropriate parties should sign and date the Loop Test Forms. All Forms shall be certified and submitted to the Engineer as part of the O&M Manuals.

F. Following loop testing, in no way should any parts of the loop be modified. In no way shall any wiring be re-routed or re-terminated. If any such work occurs, all affected loops shall be re-tested at no expense to the Owner.

2.6 COMMISSIONING

A. The IS shall oversee, coordinate and be present during all commissioning activities. The IS shall be responsible for obtaining the assistance of the Contractor and Subcontractors as may be required for commissioning activities.

B. Commissioning shall commence after acceptance of wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Pre-commissioning shall demonstrate proper operation of every system with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

C. Commissioning and test activities shall follow detailed test procedures and check lists accepted by the Engineer. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the Engineer, which include calculated tolerance limits for each step. Completion of system commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the Engineer with a clear and unequivocal statement that system commissioning and test requirements have been satisfied.

D. Where feasible, system commissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of field mounted automatic analog controllers or software-based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of field mounted, and software-based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

E. Electronic control stations incorporating proportional, integral, or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

END OF SECTION 40 61 21

SECTION 40 61 26 – PROCESS CONTROL SYSTEMS TRAINING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes Training requirements.

B. Related Sections

1. The Contract Documents are a single integrated document. As such, all Divisions and Sections are applicable. The Contractor and its Subcontractors are responsible to review all parts of the Contract Documents in order to provide a complete and coordinated project.

1.2 DEFINITIONS

A. The following definitions may be used throughout this section and subsections (refer to the contract drawings sheet GI-1 for instrumentation abbreviations):

1. CTC: Communications termination cabinet.
2. FAT: Factory acceptance test.
3. HMI: Human machine interface.
4. I&C: Instrumentation and control for process systems
5. IS: Instrumentation supplier.
6. LAN: Local area network.
7. LCP: Local control panel.
8. NC: Normally closed.
9. NO: Normally open.
10. OIT: Operator interface terminal.
11. PC: Personal computer.
12. PID: Control action, proportional plus integral plus derivative.
13. PLC: Programmable logic controller.
14. P&ID: Process and instrumentation diagram
15. RIO: Remote input/output
16. SCADA: Supervisory control and data acquisition.
17. SI: System Integrator.
18. UPS: Uninterruptible power supply.
19. VCP: Vendor control panel.
20. WAN: Wide area network

1.3 SUBMITTALS

A. TRAINING

1. Develop a Training Plan for the training requirements of Division 40 and submit it to the Engineer for approval. Coordinate with the Engineer and Owner the time and locations of each training session. Schedule the trainings for after the equipment has been pre-commissioned.
2. As part of the Training Plan, submit a résumé for everyone to be providing training. Training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.
3. Each training session shall include a written agenda.
4. The Contractor shall train the Owner's personnel on the maintenance, calibration and repair of instruments provided.
5. Within 10 days after the completion of each session, the Contractor shall submit the following:
6. A list of Owner personnel who attended the training.
7. A copy of the training materials used during the session with notes, diagrams and comments.

PART 2 - EXECUTION

2.1 MAINTENANCE TRAINING

A. Cover following areas as a minimum:
   1. Testing programs which can isolate faults to functional area.
   2. Theory, logic flow, physical hardware awareness, and interface connections and assembly of each equipment item.
   3. Diagnostic procedures using special and general-purpose test equipment. Theory, testing, and troubleshooting procedures given for special test equipment.
   4. Operation of computers and peripherals.
   5. Programming routines and procedures to enable students to take advantage of on-line and standby equipment for maintenance and performance verification.
   6. Present short operator's course to ensure students understand operator functions and man/machine interfaces. Explain displays and printouts so students understand how information is derived, when it is presented incorrectly, and use of guidelines to differentiate between software and hardware problems.

2.2 INSTRUMENT TRAINING

A. Cover following areas as a minimum:
   1. General principle of operation.
   2. Calibration schedule.
   3. Calibration procedure.
   4. Calibration equipment required (if needed).
   5. Recommended spare parts.
   6. Consumable part – recommended replacement schedule (e.g. Reagents, filters, probe tips) and procedure.

7. General care and maintenance with special consideration to all instruments that may require cleaning such as pressure and level elements, etc.

2.3 HMI TRAINING

A. HMI functionality.

B. How key components work; shall include, but not be limited to:
   1. Entering of set points.
   2. Using alarm matrix.
   3. Acknowledging and clearing alarms.

END OF SECTION 40 61 26

SECTION 40 71 13 – MAGNETIC FLOW METERS

PART 1 - GENERAL

1.1 SUMMARY

A. Magnetic flow meters are used to provide continuous flow measurement of the process. The flow instrument consists of a transmitter and a flow element.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall typically consist of a sensor and a transmitter. Where shown on the drawings, the transmitter may be utilized for multiple sensors. When a transmitter is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
    a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
    b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
    a. Modbus RTU (Two-Wire RS-485)

C. Each transmitter shall be powered by 115VAC (± 10%) at 60Hz unless specifically shown on the drawings as being powered by 24VDC (± 15%). Each transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 FLOW PROCESS MEASUREMENT DEVICES

A. MAGNETIC FLOW METER

1. Materials

a. All mounting hardware shall be 316 stainless steel, the instrument enclosure and the spool mag shall be rated NEMA 4X, the flow sensor liner shall be hard rubber, and the electrode material shall be Hastelloy.

b. Spool size shall be as specified on the drawings.

c. All applications with flow element below grade where no de-watering means or in submersible applications shall provide the flow element as NEMA 6P (IP-68).

d. Transmitter shall be integral or remote to the flow element as shown on the P&ID's.

2. Design and fabrication

a. Utilize characterized field principle of electromagnetic induction to produce signal directly proportional to flow rate. The meter shall use a pulsed DC magnetic field excitation.

b. Provide flanged end connections per ANSI B16 rated for piping system operating and test conditions.

c. Operating pressure: 150 psi.

d. Operating temperature: 32-150°F.

e. Grounding requirements: per manufacturer requirements. Typically, inlet and outlet grounding rings of same material as electrode.

f. When the transmitter is remote to the flow element, provide cable between flow element and transmitter. Coordinate with the installer the length of the cable required. No splices in any way will be allowed.

g. Complete zero stability shall be inherent to the meter system. The system shall have a programmable low flow cutoff.

h. Empty pipe detection to prevent false measurement when pipe is empty or partially filled.

i. Forward and reverse flow measurement and totalization as well as net flow totalization.

j. 4-20mA DC isolated output into maximum 800 ohms. Signal shall be programmable to indicate forward and/or reverse flow.

k. Provide a dry contact output for flow direction indication.

l. Provide a programmable frequency output for flow totalization.

m. ± 0.5% accuracy for flow rates above 1 fps.

3. Acceptable Manufacturers
    a. Siemens SITRANS F 5100W.
    b. Endress+Hauser Promag W 400.
    c. Rosemount 8700.
    d. ABB WaterMaster.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all transmitters five feet above floor level. Install in a location that is easily accessible and visible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 71 13

SECTION 40 71 79 – FLOW SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. A flow switch operates by conveying a trip motion proving process flow or alarming for loss of flow.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each flow switch shall accept 115VAC or 24VDC as shown on the Contract Drawings. It shall have two SPDT outputs rated at 5A up to 240VAC.

B. Each flow switch shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the flow switch shall be protected from the sun such that direct sunlight will not shine on the display.

C. All flow switch shall be waterproof and made from corrosion resistant materials.

D. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 FLOW PROCESS MEASUREMENT DEVICES

A. FLOW SWITCHES

1. Thermal dispersion type flow switches

a. Thermal dispersion type flow switches shall be used for pump discharge monitoring, chemical injection monitoring, gas flow monitoring and for flows in pipes with velocities greater than 0.25 fps.

b. The flow element shall be constructed of a material that is best suited for the liquid or gas that it is serving. Typically for chemicals the material will be Hastelloy C and for other liquids or gases it will be 316SS.

c. The switch shall be capable of operating in liquids or gases whose temperatures range from -40°F to 350°F and up to 2000 psi operating pressure.

d. The flow switch assembly shall be insertion type with ¾" male NPT threads. The insertion length shall be such that the thermal dispersion elements are in the center of the pipe.

e. The flow switch shall accept 115VAC or 24VDC as shown on the Contract Drawings. It shall have two SPDT relay outputs rated at 5A up to 240VAC.

f. The flow switch shall be rated to be installed in Class 1, Division I Groups B,C & D hazardous locations. The electronics shall be housed in a powder coated aluminum enclosure that is rated NEMA 4X.

g. Acceptable Manufacturers:
   1) Fluid Components International (FCI) FLT93 Series.
   2) Sierra Instruments Innova-Switch Series.
   3) Or Approved Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 71 79

SECTION 40 72 23 – RADAR LEVEL METERS

PART 1 - GENERAL

A. Radar level instruments are used to provide continuous noncontact level measurement of the process. The radar instrument consists of a transmitter, a radar antenna, and a receiver.

1.2 ACTION SUBMITTALS

A. Product Data:
   A. Dimensional Drawings
   B. Materials of Construction
   C. Measurement Accuracy
   D. Range and range ability
   E. Enclosure Rating
   F. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

   A. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
      a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)

   B. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
      a. Hart Protocol

B. Each radar transmitter shall be loop powered unless specifically shown on the drawings as being powered externally. Each transmitter shall retain its programmable settings in non-volatile memory.

C. Each radar transmitter shall be capable of being programmed through a Bluetooth connection.

D. Each sensor and corresponding transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 RADAR LEVEL MEASURING SYSTEM

   A. The radar level measuring system shall be setup as a single loop powered transducer/transmitter assembly. For hazardous locations, the transmitter shall be rated for the area of classification that it being installed in and it shall be installed with an appropriate intrinsically safe barrier to guarantee the circuit may not normally or abnormally release sufficient electrical or thermal energy to cause ignition of a flammable or combustible atmospheric mixture.

B. All transducer/transmitter assemblies shall be rated IP68 for permanent submergence. Transmitters shall have an LCD display and shall be programmable by Bluetooth. A remote display shall be provided if no LCD is available on the transmitter.

C. The transducer shall be encapsulated in chemical and corrosion resistant material and shall be hermetically sealed. The antenna supplied (horn or rod) shall be per the recommendation of the manufacturer. It shall be capable of operating from -40°F to 140°F. The transducer shall be compatible with the level range as indicated on the Contract Drawings. As a minimum, the transducer shall be capable of measuring a range of 40 feet with ≤ 0.2-inch accuracy.

D. Coordinate with the mechanical installers the method of installing the radar system (flanged or threaded connection). It is critical that the radar level measuring system be installed according to the manufacturer's installation guidelines. Install shield sections if required. Keep the radar emission cone free of interference from pipes, beams, pouring liquids, etc. Locate the assembly away from side walls of tanks or vessels.

E. Each transmitter shall provide a 4-20mA output signal that is programmable to a user desired level range.

F. Provide a software package by the same manufacturer as the radar system that is used to commission and maintain the system. The software shall be able to configure the system, view radar echo profiles and modify the programming to suppress false echo.

G. Manufacturers:
   a. Siemens
   b. Vega
   c. Endress + Hauser

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all analyzers/transmitters five feet above floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system

shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

A. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

B. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 72 23

SECTION 40 72 43 – PRESSURE AND DIFFERENTIAL PRESSURE TYPE LEVEL METERS

PART 1 - GENERAL

1.1 SUMMARY

A. Pressure and differential pressure type level meters provide continuous level monitoring of the process. The pressure instrument consists of a transmitter and pressure measuring sensors.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall typically consist of a sensor and a transmitter.

B. Each transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
   b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
   a. Modbus RTU (Two-Wire RS-485)

C. Each transmitter shall be loop powered. Each transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 LEVEL PROCESS MEASUREMENT DEVICES

A. Submersible Level Transmitters

1. The submersible level transmitter shall consist of a submersible transducer, electronic transmitter, support cable, and interconnecting cable with cable shield and vent tube for atmospheric reference. The vent tube shall be provided with a replaceable moisture barrier. The submersible transducer shall be the strain gauge type suitable for sensing pressure equivalent to the liquid level range indicated.

2. The transducer shall have 316 stainless steel process wetted parts and shall be provided with a waterproof interconnecting cable. The transducer shall be suspended by a corrosion resistant cable as recommended by the manufacturer. The installation shall allow easy removal of the transducer and cable assembly for maintenance purposes. The electronic level transmitter shall be remote mounted and shall produce a 4 - 20 mA DC signal linearly proportional to the level range indicated and be capable of driving a load of 700 ohms.

3. The interconnecting cable shall have a pull strength of 200 pounds, be factory attached to the transducer, and shall be terminated in a NEMA 4X 316SS enclosure. The enclosure shall house the vent tube moisture barrier and local indication.

4. The measurement system shall be suitable for the area classification and operation over a temperature range of 32 to 122 degrees Fahrenheit with an accuracy of plus or minus 0.5 percent of span. The transmitter shall have a non-fouling, large diaphragm (greater than 2”). The diaphragm shall be protected by a spacer assembly that also allows the transducer to sit on the floor of the wet well.

5. For lengths greater than 20 feet the transducer shall have ½” threads and shall be suspended in the wet well by ½” stainless steel conduit.

6. Acceptable Manufacturers
   a. TE KPSI model 750.
   b. Mercoid model PBLT2.
   c. Wika model LH-10 with LevelGuard attachment.
   d. Or Approved Equal.

B. Flanged Level Transmitters

1. Flanged level transmitters shall be a flanged, differential pressure-sensing unit. The transmitter shall be a 2-wire device with continuously adjustable span, zero and damping adjustments, integral indicator, scaled in engineering units, with a 4-digit LCD display, solid state circuitry, and 4 - 20 mA output with HART protocol. Accuracy shall be 0.075 percent of span. Process wetted parts, bolts, flanges, adapters, drains and vents shall be stainless steel. Body and mounting brackets shall be corrosion resistant and suitable for the environment. The flanged process connection shall be 316SST ANSI Class 150 4-inch with a 3” 316SST diaphragm. The diaphragm shall extend past the flange such that it is flush with walls of the pipe. The low-pressure connection shall be 1/4-inch or 1/2-inch NPT.

2. Components**:** Diaphragm seals shall consist of a flange with flush or extended diaphragm to be flush with the walls of the pipe. It shall have a direct mount, coplanar, welded connection for connection of the transmitter to the seal.

3. Operating Principles: The diaphragm seal shall attach to the inlet connection of a pressure instrument to isolate its measuring element from the process fluid. The space between the diaphragm and the pressure element shall be completely filled with a suitable liquid that is rated for the environmental conditions. Displacement of the liquid fill in the

pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch, or other pressure instrument.

4. Materials: Exposed surfaces, housings, and diaphragm shall be constructed of 316, stainless steel.

5. Acceptable Manufacturers
   a. Rosemount model 3051SAL with model 1199 diaphragm seal.
   b. Siemens Sitrans P320 with diaphragm seal
   c. Or Approved Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all transmitters five feet above floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 72 43

SECTION 40 72 76 – LEVEL SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Level switches provide point level measurement of the process.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each level switch system shall typically consist of a sensor and an output contact.

B. Each level switch shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. Form C dry type contacts rated for 10A up to 250VAC.

C. Each level switch shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the level switch shall be protected from the sun such that direct sunlight will not shine on the display.

D. All level switches shall be waterproof and made from corrosion resistant materials.

E. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 LEVEL PROCESS MEASUREMENT DEVICES

A. FLOAT SWITCHES

1. Float switches shall consist of a mechanical switch, hermetically sealed in a plastic casing, freely suspended at the desired height from its own cable. When the liquid level reaches the float switch, the casing will tilt, and the mechanical switch will change state.

2. The casing shall be constructed of polypropylene with the sheathed cable extruding from the casing. The cable shall be three conductors, made specifically for underwater use and heavy flexing service.

3. The float switch shall have a 10A resistive rating up to 250VAC.

4. Weight and buoyancy shall be such that contaminants like a cake of grease will not result in the float switch changing operating level more than one inch.

5. A NEMA 4X 316SS junction box shall be supplied for termination of the float cable(s) allowing for conventional wiring and conduit to be run from the junction box to a control panel. It shall have terminal blocks for the required number of circuits and shall accept sealed fittings.

6. Float switch cables shall be suspended in a manner that provides minimum strain to the cable and will not damage it. This is typically achieved with a stainless-steel cord support grip or strain relief grip as manufactured by Kellems. When support grips are used, a stainless-steel hook shall be installed for hanging the support. All screws, fasteners, boxes, and grips shall be 316SS. In no way are any steel or galvanized steel components allowed.

7. The float cable length shall be long enough for easily removing the float from the water for testing and long enough to reach its termination junction box.

8. If the float switch is to be installed in a classified area, an appropriate intrinsically safe barrier shall be utilized to guarantee the circuit may not abnormally create an ignition.

9. Manufacturers:
   a. Flygt ENM-10.
   b. Or Approved Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 72 76

SECTION 40 72 83 – LEAK DETECTION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Float switch style leak detection is used to provide a flood warning for a building or other enclosed space. This is used to detect when a piping or pump system has failed.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating
   7. Power
   8. Output options

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each leak detection float switch shall typically consist of a float and a contact to communicate with the SCADA system.

B. Each leak detection float switch shall be equipped with means to transmit alarm information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. Form A dry contact rated for 20VA at up to 240VAC.

C. Each float switch shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners.

D. All analyzers/transmitters shall be waterproof and made from corrosion resistant materials.

E. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 LEVEL PROCESS MEASUREMENT DEVICES

A. FLOOD SWITCHES

1. High level flood switches shall be the type that is suspended on a column. A ¼" NPT connection with flying leads allows the column and float assembly to be attached to a junction box. The junction box shall be rated NEMA 4X and be nonmetallic. The flood switch shall be CPVC and shall be made for use with liquid chemicals and corrosive liquids. Switch contacts shall be SPST N.O. with 20VA rating minimum.

2. If the flood switch is to be installed in a classified area, an appropriate intrinsically safe barrier shall be utilized to guarantee the circuit may not abnormally create an ignition.

3. Manufacturers:
   a. GEMS LS-74780.
   b. Or Approved Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the float switch systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 72 83

SECTION 40 73 13 – PRESSURE AND DIFFERENTIAL PRESSURE GAUGES

PART 1 - GENERAL

1.1 SUMMARY

A. Pressure and differential pressure gauges provide continuous pressure measurement of the process for local indication.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. All gauges shall be waterproof and made from corrosion resistant materials.

2.2 PRESSURE PROCESS MEASUREMENT DEVICES

A. General

1. All inline pressure instruments shall be supplied with isolation ball valve and bleed needle valve for each measurement point. Valve materials shall be selected based upon the properties of the liquid or gas and the atmosphere.

2. Unless otherwise indicated on the Contract Drawings, pressure process measurement devices shall measure process pressure relative to atmospheric pressure (gauge pressure).

3. Pressure process measurement devices which are to measure differential pressure shall have the appropriate inlet and outlet ports and isolation and bleed valves for each port.

4. All pressure instrumentation shall be properly mounted, ideally in locations that are easily accessible and viewable. Supply all appropriate mounting poles, plates, and accessories such that each instrument is properly supported and mounted.

B. Pressure Gauges

1. Pressure gauges shall be 4-1/2 inches in diameter with white laminated dials and black graduations. Windows shall be shatterproof glass acrylic. Gauges shall have a blowout disc and be encased in phenolic, steel, or cast iron. Measuring element shall be a stainless-steel bourdon tube with welded, stress-relieved joints. Socket shall have wrench flats. Movement shall be rotary geared stainless-steel material. Gauges shall perform as a liquid-filled gauge in a dry gauge and fight against vibration and pulsations. Gauges shall be calibrated to read in applicable units. Accuracy shall be plus and minus 1/2 percent range to 150 percent of the working pressure or vacuum of the pipe or vessel to which they are connected.

2. Acceptable Manufacturers
   a. Ashcroft 1279.

b. Or Approved Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems.

B. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 73 13

SECTION 40 73 29 – DIFFERENTIAL PRESSURE TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY

A. Differential pressure transmitters are used to provide continuous pressure monitoring of the process.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall consist of a sensor and a transmitter.

B. Each transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
   b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
   a. Modbus RTU (Two-Wire RS-485)

C. Each transmitter shall be loop powered Each transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors shall be rated for permanent submersion and shall be corrosion resistant.

2.2 PRESSURE PROCESS MEASUREMENT DEVICES

A. General

1. All inline pressure instruments shall be supplied with isolation ball valve and bleed needle valve for each measurement point. Valve materials shall be selected based upon the properties of the liquid or gas and the atmosphere.

2. Unless otherwise indicated on the Contract Drawings, pressure process measurement devices shall measure process pressure relative to atmospheric pressure (gauge pressure).

3. Pressure process measurement devices which are to measure differential pressure shall have the appropriate inlet and outlet ports and isolation and bleed valves for each port.

4. All pressure instrumentation shall be properly mounted, ideally in locations that are easily accessible and viewable. Supply all appropriate mounting poles, plates, and accessories such that each instrument is properly supported and mounted.

B. Pressure Transmitters

1. Electronic differential pressure transmitters shall consist of a capsule assembly, bottom works, vent plug, drain plug, cover flange, ½" NPT process connector and connection, amplifier unit, integral indicator, terminal box with cover, block and bleed valves, and conduit connections.

2. Transmitter shall be rated NEMA 4X. For hazardous locations, it shall be installed with an appropriate intrinsically safe barrier to guarantee the circuit may not abnormally create an ignition.

3. Transmitter shall be of a two-wire, 24VDC loop powered, producing 4 to 20 mA output proportional to the calibrated range of the instrument, capable of driving a 600-ohm load.

4. Static pressure rating shall be a minimum of 500 psig. The maximum over range pressure limit shall be a minimum of 150% of the range. Span shall be adjustable over a minimum of 5:1 range.

5. The 4 to 20 mA signal shall be capable of being calibrated electronically. Output signal damping shall be provided as an internal adjustment. Equipment shall be suitable for an ambient operating range of -40°F to +176°F. The transmitter shall be equipped with the Hart protocol.

6. Accuracy, including linearity and repeatability, shall be a plus or minus 0.2 percent of span. Gauge pressure transmitters used for flow service shall include square root extraction to produce an output signal linearly proportional to flow. Wetted parts, including block and bleed valve parts, shall be constructed of 316 stainless steel.

7. Acceptable Manufacturers
   a. Rosemount 2051.
   b. Siemens SITRAN P320.
   c. Endress + Hauser Cerabar PMC51.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all transmitters five feet above floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 73 29

SECTION 40 73 36 – PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Pressure and differential pressure switches are used to prove a process condition for interlocking or alarming.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each pressure switch shall be equipped with contacts shall be rated for a minimum of 5 Amps at 120 VAC.

B. Each pressure switch shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the pressure switch shall be protected from the sun such that direct sunlight will not shine on the display.

C. All pressure switch shall be waterproof and made from corrosion resistant materials.

2.2 PRESSURE PROCESS MEASUREMENT DEVICES

A. General

1. All inline pressure instruments shall be supplied with isolation ball valve and bleed needle valve for each measurement point. Valve materials shall be selected based upon the properties of the liquid or gas and the atmosphere.

2. Unless otherwise indicated on the Contract Drawings, pressure process measurement devices shall measure process pressure relative to atmospheric pressure (gauge pressure).

3. Pressure process measurement devices which are to measure differential pressure shall have the appropriate inlet and outlet ports and isolation and bleed valves for each port.

4. All pressure instrumentation shall be properly mounted, ideally in locations that are easily accessible and viewable. Supply all appropriate mounting poles, plates, and accessories such that each instrument is properly supported and mounted.

B. Pressure Switches

1. For unclassified locations, pressure switches shall be housed in a NEMA 4X enclosure. For classified locations, pressure switches shall be housed in a NEMA 7 enclosure.

2. Gauge and Differential pressures switches shall be diaphragm-actuated, dual adjustable, with SPDT snap action switch. Contacts shall be rated for a minimum of 5 Amps at 120

VAC. The dead band shall be adjustable up to 60 percent of full scale. Set points shall fall between 20 and 80 percent of the adjustable range. The diaphragm shall be Buna-N, unless otherwise indicated, and the lower housing shall be brass with a 1/4-inch bottom sensing connection, unless otherwise indicated.

3. Acceptable Manufacturers
   a. Ashcroft Series B (Gauge) and D (Differential).
   b. Or Approved Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all pressure switches five feet above floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 73 36

SECTION 40 73 63 – DIAPHRAGM SEALS

PART 1 - GENERAL

1.1 SUMMARY

A. Diaphragm seals provide a means to measure pressure while keeping the pressure sensing device isolated from the process. These are commonly used for services that would plug the small passages in the pressure sensing device.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each diaphragm seal shall consist of a diaphragm, fill fluid, and piping connection for mounting of transmitter. Each unit shall be arranged and designed to directly transmit the process measure by means of fluid through an opening in the lower housing to a pressure sensing device attached and sealed to the upper housing. Diaphragm seals shall be factory assembled to the pressure sensing device.

B. All diaphragm seals shall be made from corrosion resistant materials.

2.2 PRESSURE PROCESS MEASUREMENT DEVICES

A. Inline Pressure Diaphragm Seals

1. Diaphragm seals shall consist of bottom housing, lower ring, diaphragm capsule, fill screw, flushing connection, and a top housing.

2. The diaphragm seal shall attach to the inlet connection of a pressure instrument to isolate its measuring element from the process fluid. The space between the diaphragm and the pressure element shall be completely filled with a suitable liquid. Displacement of the liquid fill in the pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch, or other pressure instrument. The diaphragm seal shall have a removable bottom housing to permit servicing. The diaphragm seal shall be factory assembled to the corresponding pressure instrument and be factory-filled. The assembly shall be shipped with a tag reading "Do not disassemble for installation."

3. For sewage, sludge, liquids containing solids, corrosive gases, provide seals with 316SS diaphragm and housing. Nuts, bolts, fill connection and valved flush components shall also be 316SS.

4. For chemical solutions and for liquids or gases that will corrode 316SS, provide seals with PVC body and Viton FKM (for vacuum and up to 15 PSI) or PTFE (for above 15 psi) diaphragm material.

5. Acceptable Manufacturers
   a. Ashcroft model 101 (for 316SS diaphragm seals).

b. Plast-O-Matic Valves Inc. Series GGS (for PVC body diaphragm seals).
c. Or Approved Equal.

B. Flanged Large Diaphragm Seals

1. Flanged type diaphragm seals shall be used where clogging and/or high accuracy is required. The flanged housing shall be constructed of 316SS.

2. The diaphragm seal shall consist of a flange with flush or extended diaphragm such that the diaphragm surface is flush with the walls of the pipe surface. It shall have a direct mount, coplanar, welded connection for connection of the pressure sensor to the seal.

3. The diaphragm seal shall attach to the inlet connection of a pressure instrument to isolate its measuring element from the process fluid. The space between the diaphragm and the pressure element shall be completely filled with a suitable liquid that is rated for the environmental conditions. Displacement of the liquid fill in the pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch, or other pressure instrument.

4. Acceptable Manufacturers
   a. Rosemount Series 1199.
   b. Or Approved Equal.

C. Annular Ring Diaphragm Seals

1. The pressure sensing ring shall measure pressure for 360 degrees around the full inside circumference of the pipeline. The sensing ring shall also be clamped into the body for the full radial width of the sensor. Pressure shall be transmitted to the gauge by a locked in and sealed fluid such as ethylene glycol or silicone oil. The annular seal shall be factory-assembled to the corresponding pressure instrument and be factory filled. The assembly shall be shipped with a tag stating, "Do not disassemble for installation."

2. The annular ring shall be rated for ASME classes 150 and 300. It shall be constructed of carbon steel. Instrument connection shall be ¼" NPT.

3. The inside diameter of the sensor shall be the same as the mating pipe for a full uninterrupted flow. There shall be no dead ends or crevices, and flow passage shall make the sensor self-cleaning. The sensor shall have an auxiliary tapped and plugged port to allow connection of other equipment.

4. Wetted parts (liner) shall be capable for continuous duty handling a slurry containing 15 percent solids in a hydrocarbon oil similar to kerosene at temperatures up to 225 degrees F.

5. Acceptable Manufacturers:
   a. Ashcroft model 80.
   b. Red Valve Series 48W.
   c. Noshok Type 40

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 73 63

SECTION 40 74 63 – TEMPERATURE TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY

A. Temperature transmitters convert signals from RTD's or thermocouples into analog signals that the SCADA system can use.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating
   7. Power
   8. Output options

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall consist of a sensor and an a transmitter. Where shown on the drawings, the transmitter may be utilized for multiple sensors. When a transmitter is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
    a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
    b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
    a. Modbus RTU (Two-Wire RS-485)

C. Each transmitter shall be loop powered with a voltage range of 10.5-30VDC. Each transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All transmitters shall be waterproof and made from corrosion resistant materials.

2.2 TEMPERATURE PROCESS MEASUREMENT DEVICES

A. General

1. Temperature monitoring instrumentation for HVAC and room temperature monitoring are specified elsewhere.

B. Temperature Transmitters

1. Temperature transmitters shall be 2 wire devices with continuously adjustable span and zero adjustments, integral direct reading indicator, solid state circuitry, and a 4 - 20 mA DC output linearly proportional to the indicated temperature span.

2. Measurement accuracy shall be ≤0.3°F

3. Acceptable Manufacturers
   a. Transmitter Assemblies
      1) Rosemount 3144P.
      2) Siemens TF320
      3) Endress + Hauser iTemp TMT142

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all transmitters five feet above floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. All temperature transmitters provided shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations need adjustment. Such adjustments, if required, shall be made only after consultation with the Engineer.

D. Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. For each instrument calibration, provide a calibration sheet and update the corresponding TR20 Instrument Form with the new calibration data. The Calibration sheet shall include the following as a minimum:
   1. Date of calibration
   2. Project Name.

3. Tag Number.
4. Manufacturer, model, and serial number.
5. Calibration data including range, input, output, and measurement at each calibration point.
6. Space for comments.
7. Space for sign-off by party performing calibration.

F. A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the Engineer. The IS shall sign the tag when calibration is complete. The Engineer will sign the tag when the calibration and testing has been accepted.

G. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 74 63

SECTION 40 74 66 – TEMPERATURE SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Temperature switches provide alarm or interlock monitoring of the process to the SCADA system.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating
   7. Power
   8. Output options

B. Instrumentation TR20 forms.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Instrumentation TR20 forms.

1.4 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.5 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each temperature switch shall consist of a sensing bulb and an output contact.

B. Each temperature switch shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. A form C dry contact with 15A 250VAC rating.

C. Each temperature switch shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners.

D. All temperature switches shall be waterproof and made from corrosion resistant materials.

E. All sensors shall be rated for permanent submersion and shall be corrosion resistant.

2.2 TEMPERATURE PROCESS MEASUREMENT DEVICES

A. General

1. All temperature sensors or gauges to be used for monitoring temperature of liquids or gases shall be equipped with a thermowell. Thermowells shall have a minimum wall thickness between bore and outside of well of 3/16". Wells shall have one-inch male NPT process connections except where line classification indicates some other type. Element connections shall be 1/2-inch female NPT. Material shall be Type 316 stainless steel

unless the process requires otherwise. Flanged thermowells, where required, shall meet material and size requirements of the line classification. Insertion length shall be specific to the application, not exceeding the manufacturer's published recommendations for the allowable length and for the line velocity.

2. Temperature monitoring instrumentation for HVAC and room temperature monitoring are specified elsewhere.

B. Temperature Switches

1. The temperature sensing element shall be constructed of 316SS.

2. The switch shall be capable of operating in liquids or gases whose temperatures range from -40°F thru 750°F.

3. Thermowells must be used if the stem of the temperature switch may be exposed to pressure, corrosive fluids, or high velocity. Thermowell bushings shall be used with remote mount temperature switches.

4. Temperature switches shall have a repeatability of ±1.0% of span setpoint.

5. Acceptable Manufacturers:
   a. Ashcroft B-Series.
   b. Barksdale MT1H.
   c. Other approved Manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all temperature switches five feet above floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 74 66

SECTION 40 75 43 – DISSOLVED OXYGEN ANALYZERS

PART 1 - GENERAL

1.1 SUMMARY

A. The dissolved oxygen analyzer provides continuous dissolved oxygen level measurement of the process.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating
   7. Power
   8. Output options

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall typically consist of a sensor and an analyzer. Where shown on the drawings, the analyzer may be utilized for multiple sensors. When an analyzer is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each analyzer shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
   b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
   a. Modbus RTU (Two-Wire RS-485)

C. Each analyzer shall be powered by 115VAC (+/- 10%) at 60Hz unless specifically shown on the drawings as being powered by 24VDC (+/- 15%). Each analyzer shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding analyzer shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the analyzer shall be protected from the sun such that direct sunlight will not shine on the display.

E. All analyzers shall be waterproof and made from corrosion resistant materials.

F. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 DISSOLVED OXYGEN PROCESS MEASUREMENT DEVICES

A. Each DO analyzer shall be rated for operation with ambient temperature within -4°F to 122°F. If the analyzer is to be installed in locations that may experience temperatures less than -4°F, it shall be housed in an enclosure which is equipped with a thermostatically controlled heater. If

the analyzer is to be installed in locations that may exceed 122°F, it shall be housed in an air-conditioned enclosure. All enclosures and air conditioners shall be rated NEMA 4X.

B. The DO Sensor assembly shall meet the following criteria:

1. Contain the sensing elements and electronics for digital communications to the analyzer in a self-contained, corrosion-resistant, and submersible housing.
2. Built-in temperature compensation.
3. Allowed to be installed in liquids whose temperatures are 32 to 200°F and whose pressure is up to 100 psi.
4. The sensor shall have a measuring range of 0 to 20 ppm.
5. The sensor shall continuously measure dissolved oxygen by exciting a luminescent material and then detecting light emitted by the material that is proportional to the amount of dissolved oxygen in the liquid.

C. Shall not require sample conditioning or electrolyte solutions.

D. Acceptable Manufacturers:

1. Hach model LDO Probe 2 with SC200 or SC1000 analyzer/transmitter.
2. WTW/Xylem FDO 700 IQ with 182 or 2020 analyzer/transmitter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all analyzers five feet above floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 75 43

SECTION 40 75 53 – TURBIDITY ANALYZERS

PART 1 - GENERAL

1.1 SUMMARY

A. The turbidity analyzer provides continuous turbidity level measurement of the process.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Dimensional Drawings
   2. Materials of Construction
   3. Measurement Accuracy
   4. Range and range ability
   5. Enclosure Rating
   6. Classification Rating
   7. Power
   8. Output options

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. All submittals as required in 40 61 13.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations, and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

C. All process lower and upper ranges to be coordinated with Engineer prior to instrument submittals being submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's and as required in section 26 05 00. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall typically consist of a sensor and an analyzer. Where shown on the drawings, the analyzer may be utilized for multiple sensors. When an analyzer is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each analyzer shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
   b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
   a. Modbus RTU (Two-Wire RS-485)

C. Each analyzer shall be powered by 115VAC (+/- 10%) at 60Hz unless specifically shown on the drawings as being powered by 24VDC (+/- 15%). Each analyzer shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding analyzer shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the analyzer shall be protected from the sun such that direct sunlight will not shine on the display.

E. All analyzers shall be waterproof and made from corrosion resistant materials.

F. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 TURBIDITY PROCESS MEASUREMENT DEVICES

A. Each turbidity analyzer shall be rated for operation with ambient temperature within -4°F to 122°F. If the analyzer is to be installed in locations that may experience temperatures less than -4°F, it shall be housed in an enclosure which is equipped with a thermostatically controlled

heater. If the analyzer is to be installed in locations that may exceed 122°F, it shall be housed in an air-conditioned enclosure. All enclosures and air conditioners shall be rated NEMA 4X.

B. The Turbidity Sensor assembly shall meet the following criteria:

1. Contain the sensing elements and electronics for digital communications to the analyzer in a self-contained, corrosion-resistant housing.
2. The turbidity sensor shall be meet the performance criteria of the U.S. Environment Protection Agency in Method 180.1, making it suitable for regulatory reporting.
3. The sensor shall utilize a light source that directs light through the process water to a submerged photocell which detects the amount of light that passes through the water.
4. Allowed to be installed in liquids whose temperatures are 32 to 122°F.
5. The sensor shall have a measuring range of 0 to 100 NTU.
6. Shall not require sample conditioning or electrolyte solutions.

C. Acceptable Manufacturers:
1. Hach model TU5300 Turbidity System with SC200 or SC1000 analyzer/transmitter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all analyzers five feet above floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 40 61 21 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid, and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration. These shall be submitted as part of the O&M manual as called for in section 40 61 13.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 40 61 26.

END OF SECTION 40 75 53

SECTION 409513 – PROCESS CONTROL PANELS AND HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes the requirements for all control panels and associated hardware for the project. This includes, but is not limited to, vendor control panels, PLC panels, local control panels and instrumentation panels.

B. Related Requirements:
   1. The requirements of Division 26 shall apply to this section.

1.2 ACTION SUBMITTALS

A. Submit the Control Panels Submittal as required by Section 409000.

1.3 CLOSEOUT SUBMITTALS

A. Submit the operation and maintenance data, including record control panel drawings for all control panels as required by Section 409000.

1.4 QUALITY ASSURANCE

A. Referenced Standards:

   1. National Electric Code (NEC).
   2. American Society for Testing and Materials (ASTM).
   3. Joint Industrial Council (JIC).
   4. National Electrical Manufacturers Association (NEMA):
      a. ICS 4, Terminal Blocks for Industrial Use.
      b. ICS 6, Enclosures for Industrial Controls and Systems.
      c. 250, Enclosures for Electrical Equipment (1000 V Maximum).
   5. Underwriters Laboratories Inc. (UL):
      a. 50, Enclosures for Electrical Equipment.
      b. 508, Industrial Control Equipment.
      c. 508A, Standard for Industrial Control Panels.

B. Hardware to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. All panels shall be assembled in and labeled by a listed UL 508A panel shop. However, this shall not be construed

as relieving the Contractor from responsibility for the proper installation and functionality of the work.

C. Examine the Contract Documents and verify that control panel hardware being provided is compatible with the requirements. Provide all necessary accessories to the control panels for a complete and operable system.

D. The Contractor shall not place any conduit feeds for any control panel until the Control Panel Submittal has been approved. Once approved, conduits shall be placed strategically to best suit the layout of the control panel. Power entry and separation of power, controls and signal shall be considered.

E. All painted control panels shall have matching paint colors and tones.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the control panel hardware as required by Section 409000.

PART 2 - PRODUCTS

2.1 GENERAL

A. All control panels shall have an overall NEMA rating suitable for withstanding the mechanical, electrical, thermal stresses, humidity and corrosion that the panel will be subjected to in its installed location.

B. The following rules shall be followed when determining the NEMA rating requirement for each control panel:

1. NEMA 1, 3 & 3R shall not be allowed for control panels.
2. NEMA 4 shall be utilized for outdoor or wet locations in non-corrosive, unclassified areas. NEMA 4 control panels shall be painted steel.
3. NEMA 4X shall be utilized in corrosive, unclassified areas. NEMA 4X enclosures shall be 316SS except for the following exceptions with which the enclosure shall be polycarbonate or fiberglass reinforced polyester (FRP):
   a. Chemical areas or rooms.
   b. Locations where stainless steel is incompatible.
   c. Where specifically noted on the Contract Drawings.
4. NEMA 7 shall be utilized for classified areas as required by NEC. NEMA 7 enclosures shall be constructed of cast aluminum.
5. NEMA 12 shall be utilized in dry, non-corrosive, unclassified areas. NEMA 12 control panels shall be painted steel.

C. Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks or a disconnect operable from the control panel front. Each control panel shall be provided with identified terminal strips for the connection of external conductors. The SUPPLIER

shall provide sufficient terminal blocks to connect 30 percent additional conductors for future use.

D. PLC Discrete outputs from the control panel shall be provided by electrically-isolated contacts rated for 10 amps at 120 VAC. Analog inputs and outputs shall be isolated 4 to 20 mA, 2 wire signals with power supply.

E. Control panel mounted devices shall be mounted a minimum of 3-feet above finished floor elevation. Touchscreens shall be mounted at a height of 66" from the finished floor to the center of the touchscreen. All control panels will be situated on housekeeping pads, this is not considered the finished floor elevation.

2.2 ENCLOSURES

A. Enclosures shall be either freestanding, pedestal-mounted or equipment skid-mounted, as indicated. Internal control components shall be mounted on an internal back-panel or side-panel as required.

B. Enclosure dimensions indicated on the Contract Drawings are based upon non-certified information and shall be considered the minimum panel size. It is the responsibility of the Contractor to design the size of all control panels. When sizing the control panels, adhere to the following criteria:
   1. Maximum panel depth is 24". If there are special reasons for a deeper enclosure, approval must first be obtained from the Engineer.
   2. The panel size shall provide space for all equipment, wire-ducts, wire, terminations, and space for future expansion.
   3. If the panel size needs to be enlarged, coordinate with the installing Contractor that there is adequate space for the larger size. If there is not space, coordinate with the Engineer to come up with a solution.

C. Materials
   1. Steel panel section faces shall be 12-gauge minimum thickness for free standing panels and 14-gauge minimum thickness for wall-mounted or pedestal-mounted panels. Materials shall be selected for levelness and smoothness.
   2. Structural shapes and strap steel shall comply with ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates, Grade C.
   3. Bolting Material: For outdoor, wet or corrosive areas, all bolting materials shall be 316SS. In dry, non-corrosive locations, carbon steel may be used. Commercial quality bolts, nuts, and washers shall be 1/2-inch diameter with UNC threads. Carriage bolts shall be used for attaching end plates. Other bolts shall be hex end machine bolts. Nuts shall be hot pressed hex, American Standard, heavy. Standard wrought washers shall be used for foundation bolts and attachments to building structures. Other bolted joints shall have SAE standard lock washers.
   4. Control panels shall be structurally designed such that the completed and installed control panels shall safely withstand seismic requirements for the project. All equipment mounted within the panel shall be properly braced to prevent damage during a seismic event.

D. Acceptable Manufacturers
   1. Hoffman.
   2. Saginaw.
   3. Or Approved Equal.

2.3 CONTROL PANEL ASSEMBLY

A. General

   1. The following requirements must be met when mounting to the back panels or side panels of the control panel:
      a. Holes shall be drilled and tapped with less than 50% diminishment in thread.
      b. Backpan shall be cleaned front and back after any drilling and tapping.
      c. Tek Screws are not acceptable.
      d. Any component mounted to a back panel or side panel shall be mounted at an exact square to the vertical and horizontal planes.
      e. Any duct running between back panels and side panels shall align horizontally with no overlaps.
      f. All DIN rail mounted to the panels shall have ½" stand-offs allowing for wires and other equipment to be routed beneath the rail if necessary.
   2. Enclosure doors shall be flush fitting, gasketed, and be of the hinged lift-off type with lockable door handles. A common key shall be provided for the doors on each panel assembly. Removable access panels shall be provided with dished handle fasteners. Screw driver 1/4 turn or Dzus type fasteners are not acceptable.
      a. The flanged edges of panels shall be straight and smooth. Corners shall be welded and ground smooth.
      b. The face of the panel shall be true and level after flanging.
      c. Panel cutouts and holes may be cut or drilled by any standard method that does not cause deformation. Burrs shall be ground smooth.
      d. Adjacent panels shall assemble with faces flush. Gaps or cracks shall not be visible from the front of the assembled instrument board.
      e. Panels shall be self-supporting.
   3. Control panels that are supplied with three phase power and/or are powering motor loads shall be supplied with a main feeder disconnect that is door operated. The door operator for the disconnect shall be defeat-able with a screwdriver. If the upstream overcurrent protection device feeding the control panel is not in the same room as the control panel, provide a main circuit breaker as part of the main disconnect assembly. Fused disconnects shall not be used unless specifically shown on the Contract Drawings.

B. Preparation of Bare Metal Panel Surfaces

   1. Grind high spots, burrs, and rough spots.
   2. Sand or sandblast to a smooth, clean, bright finish.
   3. Every trace of oil shall be removed with a solvent.
   4. Apply the first coat of primer immediately.

C. Panel Finishing

1. Repair damaged primer on inside surfaces.
2. Apply primer to the entire panel surface.
3. Apply 2 coats of satin finish lacquer enamel over the entire surface.
4. Colors shall match original paint color.

D. Instrument Finishing: The final coat applied to painted surfaces of instrument cases, doors, or bezels which are visible from the front of panels shall be manufacturer's standard unless otherwise indicated. Black japan or "crinkle" finishes on instrument cases are not acceptable.

E. Mounting of Instruments

1. The panel shop shall provide cutouts and shall mount instrument items indicated to be panel mounted, including any instruments indicated to be furnished by other vendors but installed in the panel.
2. The panel shop shall also mount behind the panels other instrument accessory items as required.
3. Equipment mounted at the rear of panel shall be installed to allow for commissioning adjustments, servicing requirements, and cover removal
4. Spare space shall be kept clear of wiring, etc., to give maximum space for future additions.
5. All equipment mounted with fasteners shall be mounted with grade 5 or greater Phillips head fasteners.

F. Electrical Requirements
1. Each panel shall be serialized with its own UL serial number and label.
2. Each terminal block shall have a printed label as shown on the panel drawings. Hand written labels in any location of the panel will not be accepted. Wiring shall be identified with printed tubular wire end markers.
3. Back panels and side panels shall have visible machine printed adhesive labels that detail the following items:
    a. Terminal block torque ratings for field connections.
    b. Terminal block sections as detailed in the panel drawings.
    c. All equipment within the panel including, but not limited to, PLCs, switches, circuit breakers, UPS, Power Supplies, and any other piece of equipment.
4. Screw torque shall not exceed 0.4 N*M (4.4 Lb*In) (7 Lb-In).
5. Wire duct for AC signals and wiring shall be light grey. All duct for DC signals shall be white. Wiring for AC circuits and DC circuits must be kept within their respective ducts.
6. Freestanding panels shall be provided with switched lighting as indicated in the panel drawings.
7. Freestanding panels shall be provided with a 15 amp, 120 volt, service outlet circuit within the back-of-panel area as shown in the panel drawings.
8. Wall-mounted or pedestal-mounted panels shall be sized to adequately dissipate heat generated by equipment mounted in or on the panel.
9. Outdoor panels shall be provided with thermostatically-controlled heaters to maintain inside temperatures between above 40°F.
10. Any panel with heat producing equipment such as a PLC, UPS or VFD shall have cooling capabilities to maintain the inside temperature below 104°F.

11. All outdoor panels equipped with heating and/or cooling shall be insulated with a minimum R value of 2.0.
12. Provide a laminated fuse list matrix detailing fuse numbers and sizes mounted on the inside of the enclosure door. The fuse list matrix must be easily visible and at minimum size 14 font. Hand written fuse matrices will not be accepted. See panel drawings approximate locations.
13. Provide a pocket mount on the inside of each panel door large enough to hold type 8.5 x 11 size paper. See panel drawings for approximate locations. Pockets must be accessible with no equipment obstructing the entrance of the pocket for at least ten inches above the pocket. The pocket mount shall be fastened. No adhesive type pockets allowed.
14. Where required crimped fork or ring terminals will be properly installed on the conductors for connection integrity.
15. Signal and Control Circuit Wiring
    a. Wire type and sizes: Conductors shall be flexible stranded tin machine tool wire, UL 1015 listed Type MTW, and shall be rated 600 volts. Wires for instrument signal circuits and alarm input circuits shall be 14 AWG. Other wires, including shielded cables, shall be 16 AWG minimum.
    b. Wire Insulation Colors: Conductors supplying 120 VAC power on the line side of a disconnecting switch shall have a black insulation for the ungrounded conductor. Grounded circuit conductors shall have white insulation. Insulation for ungrounded 120 VAC control circuit conductors shall be red. Wires energized by a voltage source external to the control panel shall have yellow insulation. Insulation for DC conductors shall be blue.
    c. Wire Marking: Wire numbers shall be marked using white numbered wire markers made from plastic-coated cloth, Brady Type B 500 or equal, or shall be heat shrink plastic. Wire labels must be machine printed. All conductors within the control panel are to be permanently marked with wire labels at each end. Wire labels are to correspond to the labels on the approved shop drawings.
    d. For case grounding, panels shall be provided with a ground lug complete with solderless connector for one no. 1 AWG bare stranded copper cable.
    e. Panel doors shall be connected to panel ground.
    f. Wire Fastening: Provision shall be made utilizing cable tie bases such as type CTM1 or equivalent, fastened inside the wire duct to allow for the fastening of the shop wire harnesses upon final installation.
16. Power Supply Wiring
    a. Unless otherwise indicated, control power shall be 120 VAC. Where the electrical power supply to the control panel is something other than 120 VAC, the control panel shall be provided with a control panel transformer. Control conductors shall be provided in accordance with the indicated requirements.
    b. At a location near the top of the panel (or bottom), the panel fabricator shall provide terminal box connections for the main power supply entry.
17. Signal Wiring
    a. Signal wire shall be shielded twisted pair or triads. Cable shall be 18 AWG copper signal wires.
    b. Color code for instrument signal wiring shall be as follows:
        1) Positive (+) – Red or Clear
        2) Negative (-) – Black

c. Multiconductor cables where indicated shall consist of no. 16 AWG copper signal wires twisted in pairs with 90-C, 600 V fault insulation. A copper drain wire shall be provided for the bundle with a wrap of aluminum polyester shield. The overall bundle jacket shall be PVC.
d. RTD cabling shall be Belden 8770 cabling or equal.
e. Multi-conductor cables, wireways, and conduit shall be sized to allow for 25 percent spare signal wire.

18. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and be secured to the inside face of the panel using adhesive mounts.
19. Wiring to rear terminals on panel-mount instruments shall be in plastic wireways secured to horizontal brackets above or below the instruments in about the same plane as the rear of the instruments.

G. Labor and Workmanship: Panels shall be fabricated, piped, and wired by fully qualified workmen who are properly trained, experienced, and supervised.

2.4 CONTROL PANEL COMPONENTS

A. Nameplates and labels

1. All control components within the control panel shall be labeled with adhesive labels that have a thermal transfer type ink system on a UL-508A approved label. Labels shall be provided for marking wire ducts, terminal block sections, PLC modules, networking modules, signal isolators, intrinsic barriers, relays, breakers, power supplies, surge suppressors and all other pertinent components within the control panel.
2. All components on the exterior of the control panel shall have nameplates fabricated from black-letter, white-face laminated plastic engraving stock, Rowmark Ultramatte or equal. Engraved characters shall be block style with no characters smaller than 1/8 inch. Adhesive shall be high strength, low profile double strength, double sided as produced by Bron or Tessa or approved equal. Stainless steel fasteners shall be used in addition to the adhesive on all equipment where the fasteners do not derate the NEMA rating of the enclosure.

B. Pilot Devices

1. Provide pilot devices from a single manufacturer.
2. Pilot devices shall have NEMA ratings that match the overall control panel rating. They shall be 30mm in diameter and heavy duty.
3. All pilot devices shall have an associated nameplate that clearly describes the function of the device.
4. Pilot lights shall be LED and shall have colors as follows:
   a. The Contract Drawings shall take precedence for light colors. Refer to the P&ID's and schematics.
   b. On/Running/Opened: Green.
   c. Off/Stopped/Closed: Red.
   d. Power: White.
   e. Alarm/Fail: Red.

5. Acceptable Manufacturers
    a. Square D Types K (for NEMA 4 or 12) or Types SK (NEMA 4X).
    b. Allen-Bradley Types 800T (NEMA 4/12) or Types 800H (NEMA 4X, 7).
    c. Or Approved Equal.

C. Door Mounted Meters

1. Digital Process Meters
    a. Provide digital process meters to display a numeric process value as required by the Contract Drawings.
    b. The meter shall accept and re-transmit an analog input signal which is in proportion with the process value. The meter shall be capable of receiving the following signals:
        1) 0 or 4 to 20 mA current.
        2) 0 to 5 or 10 DC volts.
        3) RTD and Thermocouple type inputs.
    c. The meter shall be programmable to scale the numeric display to process engineering units. It shall be capable of showing up to three decimal points.
    d. The meter shall be capable of powering the input and re-transmitted signal.
    e. Acceptable Manufacturers:
        1) Precision Digital Trident Series.
        2) Red Lion PAX Series.
        3) Or Approved Equal.
2. Elapsed Time Meters (ETM)
    a. Provide ETM's for each motor and/or machine provided for the project. Each ETM shall accumulate hours in tenths of an hour.
    b. The ETM enclosure shall be panel mount, polycarbonate, shock resistant and totally sealed.
    c. Acceptable Manufacturers:
        1) Hobbs 20000 Series.
        2) Or Approved Equal.

D. Terminal Blocks

1. Terminal blocks shall mount on standard DIN rail, and be of the size required for conductors therein. A minimum of 25 percent spares shall be provided in each terminal box. No more than 2 conductors shall be allowed per termination. Jumper bar assemblies shall be installed for interconnecting terminal blocks, distributing power and signal commons. Terminal blocks shall be U.L. rated for 600 Volts, and 30 Amps, minimum.
2. Grounding terminal blocks shall be provided for instrumentation cable shields. The terminal blocks shall have distinctive 2-color bodies yellow and green, and shall be mounted to the DIN rail with metal screw down type clamps, providing a positive ground connection. One grounding terminal block shall be installed for every 2 instrument cables terminated. Grounding terminal blocks shall be U.L. rated for 600 Volts, and 20 Amps, minimum.
3. Terminal blocks shall be available in a variety of colors, including red, green, blue, gray, black, yellow, and orange.

4. DIN mount fuse holders shall have blown fuse indicators for DC and AC circuits. Fuse holders shall be of the compression clamp type. Fuse holders shall be U.L. listed, and rated for 600 Volts. Fuse sizes shall not exceed the U.L. current rating for the fuse holders.
5. Terminal blocks for 4 to 20 milliamp signals shall have knife disconnect switches, and accessible test points for testing and measurement of current loop signals, without the need for removing wire terminations.
6. Approved Manufacturers
    a. Phoenix Contact UT Series.
    b. Allen-Bradley 1492 Series.
    c. Or Approved Equal.

E. DIN Rail

1. DIN rail shall be prepunched, RoHS compliant, treated with galvanic zinc plating and passivation. Symmetrical DIN rail shall be 35 mm X 15 mm.
2. Acceptable Manufacturers
    a. Iboco Omega 3AF.
    b. Or Approved Equal.

F. Wire Ducts

1. Wire ducts shall have narrow slots (approximately every ½") to accommodate high-density terminal blocks and other hardware.
2. Wire ducts shall be made of lead-free PVC, shall be UL rated for continuous use up to 122°F, and shall be flame retardant.
3. Wire duct colors shall be as follows:
    a. Light grey for all wiring 120V and higher.
    b. White for all wiring 48V and lower.
    c. Blue for all intrinsically safe wiring.
4. Acceptable Manufacturers
    a. Panduit Type F Series.
    b. Or Approved Equal.

G. Surge Protection Devices

1. Provide a Surge Protection Device (SPD) for power feeds which feed power to the control panel.
2. Each SPD shall have a short circuit current rating that exceeds the rating of the power feed that it is protecting.
3. All SPD's shall be properly grounded to the ground grid per NEC and per the SPD manufacturer's recommendations.
4. Three phase power feeds and single phase power feeds for non-sensitive loads.
    a. Provide a parallel, DIN rail mountable, SPD whose location is immediately downstream of the main panel disconnect or circuit breaker.
    b. Capable of handling a 10kA surge current.
    c. Acceptable Manufacturers
        1) Transtector 12R Series.
        2) Or Approved Equal.

5. Single phase power feeds for control panels with sensitive electronics
    a. Provide an inline, DIN rail mountable, SPD that also provides EMI filtering.
    b. The SPD shall be capable of handling a 10kA surge current.
    c. The inline SPD shall have a set of dry contacts that indicate when the unit is healthy and operating correctly.
    d. Acceptable Manufacturers
        1) Phoenix Contact SFP Series.
        2) Or Approved Equal.
6. Low Voltage Signals
    a. Provide surge protection for low-voltage signals where shown on the Contract Drawings.
    b. Acceptable Manufacturers
        1) Phoenix Contact Termitrab.
        2) Or Approved Equal.
7. Coaxial Transmission Lines
    a. For radio type systems, provide surge/lightning protection for all coaxial lines leaving the control panel.
    b. Surge/lightning protectors shall be rated for the frequency at which signals are to be transmitted on the cabling.
    c. Acceptable manufacturers
        1) Polyphaser.
        2) Or Approved Equal.

H. Circuit Breakers

1. Circuit breakers shall meet the requirements of Section 262816.
2. Provide a main circuit breaker with panel disconnect if required as described in 2.3.A.
3. All control panels fed by 120VAC shall have a main DIN rail mounted circuit breaker.
4. The following types of loads shall be individually fed by circuit breakers:
    a. Panel mounted receptacles.
    b. UPS equipment.
    c. DC Power Supplies.
5. Circuit breakers shall be sized according to the loads they are powering.
6. Acceptable Manufacturers
    a. Square D.
    b. Cutler Hammer.
    c. Or Approved Equal.

I. Motor Controllers

1. All motor controllers shall meet the requirements of Division 26.

J. Uninterruptible Power Supplies (UPS)

1. All UPS equipment shall meet the requirements of Section 263353.
2. UPS equipment intended to be installed in control panels shall meet the following criteria:
    a. The UPS shall be UL listed and shall maintain the UL listing of the control apnel.

b. The UPS shall be properly mounted to withstand vibration and seismic requirements for the project.
c. The UPS shall be sized for 200% of the calculated panel load.
d. The UPS shall have a minimum backup time of 30 minutes unless specifically stated as otherwise on the Contract Drawings.
e. For PLC panels, the UPS shall be equipped with dry contacts for monitoring the UPS for any alarm conditions and low battery.

3. Where specifically shown on the Contract Drawings, an industrial DC UPS may be used as backup power for the control panel. This will typically be the case where all critical loads are at 24VDC.
4. Unless indicated as otherwise on the Contract Drawings, the UPS equipment shall be the line-interative type and operate at 120VAC.
5. UPS equipment shall provide surge, EMI
6. Acceptable Manufacturers
   a. Powerware 5000 series (line-interactive) or 9000 series (online).
   b. Sola SDU Series (24VDC UPS).
   c. Or Approved Equal.

K. Power Supplies

1. Provide 24VDC Power Supplies or other DC voltages as required for the application.
2. All power supplies shall be oversized for a minimum 150% of the calculated load.
3. All power supplies shall be properly protected by a DIN rail mount circuit breaker whose trip rating is per the manufacturer's recommendation.
4. All power supplies shall have a set of dry contacts that indicate when the power supply is operating normally.
5. Where shown on the Contract Drawings, provide redundant power supplies and corresponding diodes.
6. Power supplies shall meet the following criteria:
   a. Input Voltage: 100 to 240VAC.
   b. Output Voltage: ±1% of rated output.
   c. Operating Temperature: 0°C to 60°C.
   d. Built in transient surge protection.
   e. DIN rail mountable, metal housing.
7. Acceptable Manufacturers
   a. Phoenix Contact Quint Series.
   b. Or Approved Equal.

L. Signal Isolators/Converters

1. Furnish signal isolators as required that optically isolate the input signal from the output signal. If output signal is to be a different type of signal than the output than the isolator shall convert the signal as required.
2. Isolators output shall be adjustable for zero and span.
3. If input signal is part of a Hart system, the isolator shall be made specifically to pass on the Hart signal.
4. Acceptable Manufacturers
   a. Phoenix Contact.

b. Action Instruments.
c. Or Approved Equal.

M. Intrinsically Safe Barriers

1. Provide intrinsically safe barriers wherever analog or discrete input signals are coming from classified areas.
2. Intrinsically safe barriers shall be located in their own enclosure whose assembly is UL rated. Install the barriers and field wiring as per the requirements of NEC and the manufacturer's installation guidelines.
3. If input signal is part of a Hart system, the isolator shall be made specifically to pass on the Hart signal.
4. Acceptable Manufacturers
   a. Phoenix Contact.
   b. Pepperl Fuchs.
   c. Or Approved Equal.

N. Relays

1. Provide relays whose contact ratings are sized according to the load requirements and size of the protection device associated with the circuit in which the contacts are wired. As a minimum contact ratings shall be 10A resistive up to 250VAC.
2. Provide relays whose coil voltage is as required by the application.
3. Relays with DC rated coils shall have a freewheel diode installed across the coil.
4. Relays with AC rated coils shall have a surge suppressor installed across the coil.
5. Relays shall have based with relays which plug into the base. Bases shall have screw-type connections.
6. Relays shall have an LED indicating when the relay is coil is energized.
7. Provide enough relay contacts for each relay as required by the application. If the number of contacts required exceeds the number of contacts on the relay, provide additional relay(s) to provide enough sets of contacts.
8. Acceptable Manufacturers
   a. Idec R Series.
   b. Allen-Bradley 700H Series.
   c. Or Approved Equal.

O. Time Delay Relays

1. Provide time delay relays to control on and off delay times as required by the application.
2. Time delay relays shall meet the requirements of relays as listed above with the following additional requirements:
   a. Time delay shall be adjustable from 0.1 seconds to 600 hours.
   b. Timers shall be multi-function and shall be capable of providing on-delay, off-delay, cycle timing and one-shot type timing control.
3. Acceptable Manufacturers
   a. Idec RTE Series.
   b. Phoenix Contact ETD Series.
   c. Or Approved Equal.

P. Panel HVAC Components

1. Provide heating, ventilation, and air conditioning, devices in order to maintain all components within the control panel within the acceptable range as specified in Section 409000.
2. HVAC equipment shall maintain the required NEMA rating for the control panel assembly.
3. Externally mounted HVAC equipment (such as air-to-air exchangers or air conditioners) shall be housed in an enclosure whose material matches the material of the control panel. Where in corrosive environments, all components that will come in contact with outside air shall be corrosion resistant for that environment.
4. All HVAC equipment shall be UL rated. For equipment mounted on the control panel, the equipment shall have a corresponding NEMA rating.
5. Provide power as required for the HVAC equipment. HVAC loads shall be included in feeder and control power transformer sizing calculations.
6. Panel Heating
    a. Heating shall be provided when ambient temperatures are expected to fall below the allowed range as specified in Section 409000. As a minimum, heating shall be sized to keep the panel temperature at or above 50°F.
    b. Except for small anti-condensating heaters, heating equipment shall have fans which distribute the heat throughout the enclosure. Heaters shall be installed according to the manufacturer's installation instructions. Provide enough space between the heating equipment and other components such that the other components to not experience abnormally high temperatures.
    c. Provide anti-condensating heaters for all outdoor enclosures which house electronics, instrumentation and/or motor controllers.
    d. All heaters shall be thermostatically controlled by a DIN rail mounted thermostat.
    e. Acceptable Manufacturers
        1) Hoffman.
        2) Or Approved Equal.
7. Panel Ventilation
    a. Where ventilation is determined to maintain the control panel's maximum temperature as required by Section 409000, the following requirements shall be adhered to:
        1) Ventilation shall maintain the required NEMA rating for the control panel assembly.
        2) For indoor, non-corrosive locations (panels with NEMA 12 ratings), conventional ventilation with fans and vents may be used.
        3) For corrosive or outdoor locations, side or top mounted air-to-air heat exchangers shall be used.
    b. The fan(s) and corresponding vents or air-to-air heat exchangers shall be properly sized and located to move enough air through the panel to remove the generated heat as well as allow air flow across all heat generating equipment.
    c. All ventilation shall be thermostatically controlled by a DIN rail mounted thermostat.
    d. Acceptable Manufacturers
        1) Hoffman.
        2) Pfannenberg.
        3) Or Approved Equal.
8. Panel Air Conditioning

a. Where it is deemed necessary to air condition a control panel to maintain the control panel's maximum temperature as required by Section 409000, the following requirements shall be adhered to:
    1) Air conditioners shall be side or top mounted and shall be sized based upon the heat generated within the control panel, the maximum outside air temperature, and the amount of sunlight the control panel may be exposed to. Air conditioners shall be oversized by a safety factor of 25%.
    2) Air conditioners shall be thermostatically controlled by a DIN rail mounted thermostat. In addition, the air conditioner shall turn off if the panel door(s) are not closed.

b. Acceptable Manufacturers
    1) Hoffman.
    2) Pfannenberg.
    3) Thermal Edge.
    4) Kooltronics.

PART 3 - EXECUTION

3.1 FACTORY ACCEPTANCE TESTING

A. All control panels shall be factory acceptance tested (FAT) as required by Section 409000.

3.2 INSTALLATION

A. All control panels shall be installed according to the requirements of Section 409000.

B. All control panels shall be installed so that their surfaces are plumb and level.

C. All control panels shall be properly mounted so as to withstand the seismic requirements for the Site. Anchor panels securely to the wall or floor at each corner as a minimum.

D. Control panels shall have been designed according to locations for conduit entry. Floor mounted panels in electrical rooms shall have cutouts in the bottom of the enclosure that were cutout by the panel shop. All conduit holes shall be cut in the field.

E. Field wiring
    1. Wires that are terminated in control panels after permanent panel installation are deemed as field wires. Field wiring shall be installed in the allocated wire ducts and shall be properly labeled and terminated.
    2. All field wires shall be long enough to reach each corner of the enclosure. Neatly coil up extra wire length at the bottom of the enclosure. Do not use the wire ducts for storing extra wire length.

3.3 FIELD QUALITY CONTROL

A. Refer to Section 409000.

END OF SECTION 409513

SECTION 41 12 13
SHAFTLESS SCREW CONVEYOR

PART 1 GENERAL

1.1 SUMMARY

A. This section covers furnishing shaftless screw conveyor system for the conveyance of dewatered wastewater sludge from a screw press.

B. Contractor shall furnish and install:

1. Two (2) screw press loadout screw conveyors, 12” diameter x 24’ long, 30˚ inclined, shaftless screw conveyors.

C. Equipment furnished in this specification shall be fabricated and assembled in full conformity with this specification and as shown in the contract drawings. Each conveyor shall be furnished complete with all supports; all mechanical equipment required for proper operation, including complete drive units; all steel, iron, and other metal construction specified herein; and all additional materials or fabrication as required by the supplier's design.

D. All equipment included in this section shall be furnished by a single supplier who shall be responsible for the design, coordination, and the satisfactory operation of the system.

E. The shaftless screw conveyor equipment shall include, but not be limited to the following:

1. Spiral flighting.
2. Troughs and Liners.
3. Chutes.
4. Covers.
5. End Shaft.
6. End Seals.
7. Motor Reducer.
8. Mounting and Support Structure.
9. Electrical Controls.
10. Safety Accessories.

F. Contractor shall coordinate all details of the equipment with other related parts of the work. Contractor shall verify that all structures, piping, wiring, and equipment components are compatible. Contractor shall be responsible for all structural and other alterations required to accommodate equipment differing in dimensions or other characteristics from these specifications and Drawings.

G. Contractor shall install the equipment according to instructions and recommendations of the equipment manufacturer.

H. Contractor shall verify all dimensions in the field to ensure compliance of equipment dimensions with the drawings. Contractor shall notify Engineer of significant deviations.

I. Power supply for equipment is 480 Volts, 60 Hz, 3-phase. Power supply for controls is 120 VAC, 60 Hz, single phase.

J. Compliance with the requirements and stipulations specified herein may necessitate modifications to the manufacturer's standard equipment.

K. The contractor shall be responsible for ensuring a complete and operable screw conveyor system and shall establish the exact limits of work between the contractor and screw conveyor supplier.

1.2 RELATED SECTIONS

A. Section 01 22 00 – Measurement and Payment

B. Section 01 32 17 – Work Sequence

C. Section 01 33 00 – Submittals

D. Section 01 40 00 – Quality Control

E. Section 01 65 00 – Commissioning of Systems

F. Section 01 73 00 – Installation, Operation, and Maintenance Manuals

G. Division 26 – Electrical

H. Division 40 – Process Interconnections

1.3 REFERENCES

A. The design, manufacture, and installation of this equipment shall meet or exceed the applicable provisions and recommendations of the following codes and standards:

1. American Gear Manufacturers Association (AGMA)
2. American Society of Mechanical Engineers (ASME)
3. American Society of Testing and Materials (ASTM)
4. American National Standards Institute (ANSI)
5. Institute of Electrical and Electronics Engineers (IEEE)
6. National Electrical Code (NEC)

7. Occupational Safety and Health Act (OSHA)
8. Anti-Friction Bearing Manufactures Association (AFBMA)
9. American Welding Society Publications

1.4 GENERAL

A. The manufacturer shall be of established good reputation regularly engaged in the fabrication of such equipment. Unless otherwise noted, any equipment offered shall be current modifications that have been in successful regular operation under comparable conditions.

B. All electrical devices and wiring shall comply with Division 26, Electrical.

1.5 SUBMITTALS

A. Submittals shall be provided in accordance with Section 01 33 00.

B. Complete assembly, foundation, and installation drawings, together with detailed specifications and data covering materials used, power drive assembly, parts, instrumentation devices and other accessories forming a part of the equipment furnished shall be submitted for review.

C. Owners Manuals. Operations and maintenance information and equipment maintenance summary sheets shall be furnished for the equipment specified herein.

D. A manufacturer's Certificate of Satisfactory Installation is required for work under this section.

E. Submit a copy of this specification section, with addendum updates included, with each paragraph clearly-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. If deviations from the specifications are indicated and, therefore requested by the Contractor, the submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification for any requested deviations to the specification requirements, with the submittal shall be cause for rejection of the entire submittal with no further consideration. The Owner retains the right to reject any proposed deviations in favor of this specification, as written.

1.6 QUALITY CONTROL

A. Conveyors shall be inspected and operated in the shop with the actual drive unit for this project in its entire length. Conveyor longer than the required shipping lengths will have the screws tack welded together and tested in their entire length. Conveyors should be operated for a minimum of 15 minutes and observed for alignment and abnormal operation. Conveyors shall be corrected as necessary. Prior to shipment the tack welds will be broken apart and conveyors suitably prepared for shipment. A video of the test

should be supplied on disk to the contractor to be forwarded on to the engineer for record purposes. Video must be received to get paid.

1.7 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be stored, shipped, and handled as recommended by the manufacturer.

B. Equipment shall be shipped and delivered fully assembled, except where partial disassembly is required to conform to transportation regulations or for the protection of components.

1.8 WARRANTY

A. The screw conveyor manufacturer shall warrant the following components:

1. The manufacturer will warrant against any defects in material or workmanship to the screw conveyor and framework for a period of 12 months from date of substantial completion. This shall not exceed 18 months from delivery.

    a. The manufacturer shall replace any bearing that fails during the prescribed warranty period, provided the owner has lubricated and otherwise maintained the bearing in accordance with the intervals and procedures set forth in the manufacturer's operations and maintenance instruction manual.

2. The manufacturer shall warrant the framework and the coating for a period of three years from the date of substantial completion. Any defects or corrosion occurring within the warranty period shall be repaired or replaced FOB job site including on site installation costs to be paid for by the manufacturer.

3. All equipment furnished under the screw conveyor section to be free from defects in material and workmanship for a period of 24 months from substantial completion. This shall not exceed 30 months from delivery. Any warranted defects found to exist shall be corrected (repaired or replaced) at no cost to the Owner.

1.9 QUALIFICATIONS

A. Manufacturer shall have a minimum of twenty-five (25) installations of screw conveyors for sludge dewatering of similar type and size that have been in successful operation for a minimum of five (5) years. The equipment shall be designed, constructed, and installed in accordance with the best practices and methods.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. The shaftless screw conveyor system shall be designed to meet the following minimum performance and design requirements. The standards for conveyor selection shall be

based on the operational experience of the manufacturer with shaftless screw conveyors, and not standards developed for shafted screw conveyors.

PARAMETER	CONVEYOR #715	CONVEYOR #725
Cubic ft per Hour	35	35
Material	Sludge	Sludge
Material Density	65	65
Percent Solids	15-20%	15-20%
Length	24’	24’
Angle	30 deg	30 deg
Max Screw Speed RPM	20	20
Max Trough Fill	50%	50%
Min Flight OD	8.3”	8.3”
Min Spiral Weight per ft	19.6	19.6
Minimum Trough Width	12”	12”
Minimum HP	1.5	1.5
Drive Location	Outlet	Outlet
Motor Type	TEFC	TEFC
Reversing Screw	None	None

2.2 MANUFACTURERS

A. Manufacturers: Provide shaftless screw conveyors meeting the requirements of this specification from one of the following manufacturers. Manufacturers meeting the requirements of this specification but not listed here may be considered in accordance with the Contract Documents and the Instructions to Bidders.

1. JDV Equipment
2. JMS, Inc.
3. Engineer’s approved equal

2.3 GENERAL CONSTRUCTION

A. Standard screw conveyors with shafts and intermediate bearings will not be acceptable due to their inherit ability to become clogged from the stringy, sticky, gelatinous, thixotropic characteristics of the conveyed material. Conveyor rotational speeds shall not be greater than herein specified.

B. All welding shall be in accordance with the latest acceptable codes of the American Welding Society ANSI/AWS D1.1. All welds shall be continuous unless otherwise specified. Facing surfaces of bolted joints shall be shop primed. Facing surfaces of field welded components shall be beveled and match marked.

C. All structural steel shall conform to the ASTM standard specification for structural steel, designation A36-77A. All iron casting shall conform to the ASTM standard specification for gray iron casting, designation A48-76, and shall be of a class suitable for the purpose

intended. Other materials shall conform to ASTM specifications where such specifications exist; the use of such material shall be based on continuous and successful use under the similar conditions of service.

D. Sharp corners of all cut and sheared edges shall be made smooth by a power grinder.

E. Unless otherwise specified herein, all metal parts in contact with sludge shall be Type 304 stainless steel. All fasteners, pins, and anchor bolts shall be Type 316 stainless steel.

F. All bolts, nuts, washers, and other fasteners shall be AISI 316 stainless steel.

G. All stainless-steel components and structures shall be submersed in a chemical bath of nitric acid and hydrofluoric acid (pickling bath) to remove any residues that may be present on the material as a result of forming, manufacture, or handling. After removal from the pickling bath, the equipment must be washed with a high-pressure wash of cold water to remove any remaining surface debris and promote the formation of an oxidized passive layer which is critical to the long life of the stainless steel.

H. Screw conveyor shall be Manufacturer's standard product and only be modified as necessary to comply with the drawings, specifications, and specified service conditions.

I. All parts of the dewatering screw conveyor shall be designed and appropriate for the service specified and indicated and for continuous operation.

J. All parts shall be designed and manufactured to handle the forces that may be exerted on the screw conveyor during fabrication, shipping, erection, and proper operation according to the O&M manual.

K. All components shall be so balanced that jamming at any point will not result in structural failure, but will cause the drive motor to stall. All components, including the gear reducer, shall be designed to withstand, without damage or permanent distortion, the full stalling torque of the drive motor.

L. Installation of the equipment shall be in strict accordance with the contract documents and the manufacturer's instructions and shop drawings. Manufacturer shall supply anchor bolts for the equipment. Contractors shall install the anchor bolts in accordance with the manufacturer's recommendations

2.4 GENERAL ELECTRICAL REQUIREMENTS

A. All electrical work shall be performed in accordance with applicable local and national electric codes and Division 26 of the Specifications.

B. All electrical equipment controls located on the conveyor shall have NEMA 4X enclosures and wired, through PVC conduit by the Contractor, to a single common NEMA 4X terminal box.

C. All electrical equipment shall conform to applicable standard of the National Electrical Manufactures Association (NEMA) and the National Electrical Code (NEC). Both power and control equipment shall be insulated for not less than 600 volts even though operating voltages may be lower.

D. Fuse protected motor starters with thermal overloads shall be supplied for each motor furnished with the press. All motors shall be totally enclosed, fan cooled (TEFC).

E. All motors supplied shall be rated at 150 percent nameplate horsepower of the required horsepower maximum service condition.

F. Control panels shall be NEMA 4X, stainless steel. All devices within the panels shall be permanently identified. Name plates shall be provided on the face of the panel or on the individual devices as required. Nameplates shall be made of laminated phenolic materials with a white face and a black core.

2.5 SURFACE PROTECTION

A. Ferrous metals shall be hot-dipped galvanized per the latest revision of ASTM A123 specification.

B. All pre-painted purchased equipment such as electrical motors, gear boxes, etc., are to be painted with a final coat of the following system. All iron and mild steel surfaces to be painted shall be dry abrasive grit blasted to "near white metal" in accordance with SSPC-SP6 or SSPC-SP10, and in accordance with the painting section of these specifications. Grit blasted surfaces shall be painted within 24 hours to prevent rusting and surface discoloration.

1. After surface preparation, metal surfaces except for the spiral flighting shall receive a minimum of one coat of Tnemec "66-1211 Epoxoline primer" or equal, and one coat of "46H-413 Hi-Build Tnemec-tar" coal tar epoxy or equal, to provide a total minimum dry film thickness of 15 mils prior to shipment to jobsite. Stainless steel components shall be furnished unpainted.

C. The control panel enclosure shall be NEMA 4X constructed of Type 304 stainless steel. The inside of the control panel box shall be white.

D. After installation, touch-up paint shall be applied to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting. Contractor shall passivate all field welds.

2.6 SCREW CONVEYOR EQUIPMENT

A. Materials

1. Unless otherwise specified or permitted, the materials used in the fabrication of the equipment under this section shall conform to the following:

Chutes	AISI 304, ASTM A167, 18-8
Troughs, End Plates, Covers	AISI 304, ASTM A167, 18-8
Supports	AISI 304, ASTM A167, 18-8
Hoppers	AISI 304, ASTM A167, 18-8
Spiral Flighting	Cold formed, High Strength Micro Alloy Carbon Steel with a minimum hardness of 220 Brinell
Wear Liner	Ultrahigh molecular polyethelene (4.02.04A)
Bolts, Nuts, and Washers For Conveyor Supports	AISI 316, ASTM A167, 18-8
For Conveyor Trough, Lids, and Drive	AISI 304, ASTM A167, 18-8

B. Spiral Flighting

1. Spiral flighting for the shaftless screw conveyors shall be designed to convey material without a center shaft. The minimum overall spiral weight and surface pressure shall be as specified herein. The conveyor will include an inner flight to increase axial strength and capacity of the conveyor. The minimum spiral weight shall be specified herein.
2. Spiral flights shall be cold-formed high strength micro alloy steel with a minimum hardness of 220 Brinell. The spiral flights shall be designed with the stability to prevent distortion and jumping in the trough. The torsional rating of the auger flighting shall be reached at 30% of the Fy value in the extreme fiber of the flight material. Supplier shall demonstrate that, at 250% of the motor nameplate horsepower, the drive unit cannot produce more torque than the torsional rating of the flighting, and that the "spring effect" of the spiral shall not exceed + 0.8 mm per meter of length at maximum load conditions.
3. Spiral flight material, fabrication technique, strength, hardness, and overall quality are critical to the proper operation of the conveying system as herein designed. Spiral flights that do not meet the characteristics or herein specified are specifically not acceptable. Supplier shall provide certified written documentation that the spiral flights conform to the following:

Material:	Micro Alloy Steel
Hardness:	220 Brinell Minimum
Concentricity:	2.0 mm +/-

4. Supplier shall maintain a certified factory quality control program which shall include certification of spiral flighting as described herein
5. The spiral flighting shall be formed in sections from one continuous flat bar and shall be concentric to within 2mm +/-. Sectional flighting formed from plate shall not be permitted.

6. Spiral flighting shall have full penetration welds at all splice connections. The flights shall be aligned to assure true alignment when assembled in the field and shall be made in accordance with the supplier's requirements. The spiral flights shall be coupled to the end shaft by a flanged, bolted connection.
7. The connection of the spiral to the drive system shall be through a flanged connection plate that is welded to the spiral forming a smooth and continuous transformation from the flange plate to the spiral. The drive shaft shall have a mating flange and shall be bolted to the spiral connection plate.

C. Horizontal and Inclined Troughs

1. Troughs shall be similar to the dimensional standards of CEMA 300 and enclosure classification IIE. Each conveyor trough shall be U-shaped, fabricated from a minimum 1/8-inch stainless steel plate.
2. Stiffeners shall be placed across the top of the trough and fastened to both sides of the trough to maintain trough shape and act as a face seal for the covers; apply a continuous gasket, one half inch width, to the entire top face of the trough top flange and stiffeners.
3. Each trough shall be equipped with filling and/or discharge openings as required by the contract drawings. If required, each filling and discharge opening shall be flanged suitable for
4. interconnection to other devices. Any interconnecting devices such as chutes and hoppers shall be fabricated from the same material as the troughs.
5. A flanged covered drain outlet shall be provided with each conveyor to facilitate cleaning.
6. The portion of each trough that is not covered by the filling chute shall be covered by a bolted cover of a material identical to the trough. The covers shall be manufactured in maximum four foot length section to allow for access to the conveyors. To prevent unsafe access to the conveyors, quick opening covers will not be allowed.

D. Wear Liner (Anti-Wear UHMW)

1. The wear liner for each conveyor shall be fabricated of ultra high molecular weight polyethylene sintered with an anti-wear filler to reduce wear and synthetic lubricant to reduce friction. The liner shall be provided with a visual (two different color) indicator of excessive wear. The wear liner shall be furnished in maximum four foot sections, 3/8” minimum thickness, to provide ease of replacement. The liner shall be held in place with clips; no fasteners will be allowed.

E. Inlet and Discharge Chutes

1. Inlet and discharge chutes shall be provided by the conveyor supplier as shown on the drawings. All chutes shall be fabricated from the same material as the conveyor trough.

F. Conveyor Supports

1. Each conveyor shall be furnished complete with supports suitable for mounting as shown on the contract drawings and as required by the supplier's design. The supports shall be shop fabricated from structural steel shapes and plates, and shall be assembled and fitted to the conveyor prior to its delivery to the jobsite. Supports and conveyor segments shall be match marked and shipped to the jobsite for assembly by the Contractor. At a minimum, each conveyor shall be provided with supports at the inlet and discharge end, with intermediate supports as required.
2. Supports shall be fabricated of AISI 304 stainless steel or equal.
3. All shop welding shall conform to the latest standards of the American Welding Society (AWS). The supports shall be designed to avoid interference with other equipment or equipment supports.

G. Structural Design

1. All structural supporting members shall be designed such that the ratio of the unbraced length to least radius of gyration (slenderness ratio) shall not exceed 120 for any compression member and shall not exceed 240 for any tension member (of angles about Z-Z axis). In addition, all structural members and connections shall be designed so that the unit stresses will not exceed the American Institute of Steel Construction allowable stresses by more than 1/3 when subject to loading of twice the maximum design operating torque of the spiral conveyor drive motors.

H. Drive Units

1. Each spiral conveyor shall be driven by a constant-speed integral gear reducer/motor drive unit mounted to an adapter flange mounted to the end plate of the conveyor. The adapter flange shall allow the leakage of any material from the conveyor trough to atmosphere rather than into the gear reducer/ motor drive unit. Direct coupling of the gear reducer/motor drive unit to the end flange of the conveyor will not be acceptable.
2. The drive unit shall be rigidly supported so there is no visible "wobble" movement under any operating condition. In the event of a prolonged power failure or emergency system shutdown the drive system shall be designed, at a minimum, to start the conveyor from a dead stop with the trough filled throughout its entire cross sectional area and length with partially dried and hardened dewatered material.
3. Each motor shall be 460 volt, 60 Hz, 3 phase conforming to the General Equipment specifications, except as modified herein. Each motor shall be high efficiency, 40C ambient rated, 1.15 service factor and shall have Class F insulation. Motor shall have a TEFC enclosure with Design B speed/torque characteristics. Motor requirements for equipment shall be as follows:
    a. Screw Press Loadout Screw Conveyor
        1) 1.5 hp drive unit, 1750 RPM, 460 volt, 3/60 Hz, TEFC, NEMA Design B, Class F ins., 40 deg C, 1.15 s.f. energy efficient motors

I. Gear Reducers

1. All gears shall be AGMA Class II, single or double reduction, helical gear units with high capacity roller bearings. Bearings shall be designed for the thrust loads from the fully loaded startup condition and shall have a AFBMA B10 life of 30,000 hours. The reducer will be the standard air cooled unit with no auxiliary cooling. The gear reducer shall be sized with a torque service factor of 1.5 times the absorbed power or 1.1 times the motor nameplate, at the driven shaft speed, whichever is greater.
2. An adjustable greased gland packing ring consisting of two Teflon coated packing rings shall seal the drive shaft at its penetration through the end plate.

J. Motion Failure Alarm Unit

1. Each conveyor drive unit shall be equipped with a motion failure alarm unit. The location and mounting details shall be as recommended by the conveyor manufacturer. Motion sensors shall be the non contacting type using a probe with a pre-amplifier and main electronic assembly. The main electronic unit shall operate on 120 volt, single phase, 60 Hz power supply, and shall be housed in a NEMA 4X enclosure. A 0 to 60 second time delay shall be provided for startup of the conveyor.

K. Emergency Shutdown

1. Each conveyor shall be furnished with an emergency trip cord and safety switch. The cord shall run the full length of each conveyor. The trip switch shall immediately stop all conveyors when the switch is actuated.

PART 3 INSTALLATION

3.1 ONSITE SERVICES AND TRAINING

A. Before the equipment is started, the manufacturer shall make a thorough inspection of the installation to make sure the conveyor has been installed properly and that all equipment relating to it has been installed according to the manufacturers specifications.

B. The manufacturer shall provide on-site services of a qualified factory representative to inspect the equipment installation, place the units in operation and provide training to the owner's staff. The contractor shall assist the manufacturer with onsite services by starting up and operating equipment integrated with the conveyor, i.e. screw press. The services provided by the manufacturer shall be as detailed in the O&M manuals and shall include at a minimum the following:

1. Check equipment alignment and assure that there are no unusual internal stresses.
2. Calibrate all instrumentation.
3. Check lubrication in all drives.
4. Start the drives and assure they are operating properly with no binding and with correct rotation.

C. Owner staff training shall be provided in accordance with section 01 79 00.

D. Start-up services shall be considered completed when the manufacturer and contractor have demonstrated that the units are operating according to the manufacturer's specifications and without mechanical problems. The manufacturer shall submit a certificate of satisfactory installation.

E. Manufacturer shall provide a minimum of 16 hours (two 8-hour days) of onsite services in two trips to the site. To maintain dewatering operations at the WRF, the conveyors will be constructed and brought online individually on separate dates. If on site services cannot be completed in two trips due to equipment or controls being unprepared or malfunctioning, the Contractor shall be responsible for any costs associated with additional onsite services.

3.2 OPERATION MANUALS

A. Copies of Operation and Maintenance Manuals shall be furnished for each unit, as specified in Section 01 78 23. The manuals shall be prepared specifically for this installation and shall include detailed operating and maintenance instructions and specifications relative to the following; assembly, alignment, checking, lubrication, placing in operation, adjustment, maintenance of each unit of equipment, auxiliaries furnished under this contract, together with complete parts lists, and copies of dimension drawings.

END OF SECTION

SECTION 43 05 10
EQUIPMENT GENERAL PROVISIONS

PART 1 GENERAL

1.1 DESCRIPTION

A. Scope:

1. This section specifies general requirements which are applicable to all mechanical equipment. The Supplier is responsible for ensuring that all mechanical equipment meets the requirements of this section in addition to the specific requirements of each individual equipment specification section.

B. Equipment Lists:

1. Equipment lists, presented in these specifications and as specified on the drawings, are included for the convenience of the Supplier and are not complete listings of all equipment, devices and material required to be provided under this contract. The Supplier shall prepare his own material and equipment takeoff lists as necessary to meet the requirements of this project manual.

1.2 QUALITY ASSURANCE

A. Arrangement:

1. The arrangement of equipment shown on the drawings is based upon information available to the Owner at the time of design and is not intended to show exact dimensions conforming to a specific Supplier. The drawings are, in part, diagrammatic, and some features of the illustrated equipment installation may require revision to meet actual submitted equipment installation requirements; these may vary significantly from Supplier to Supplier.

B. References:

1. This section contains references to the documents listed below. They are a part of this section as specified and modified. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall

mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, has been discontinued or has been replaced.

Reference	Title
ABMA Std 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA Std 11	Load Ratings and Fatigue Life for Roller Bearings
ANSI B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Gray Iron Pipe Flanges and Flanged Fittings, (Classes 25, 125, and 250)
ANSI B18.2.1	Square and Hex Bolts and Screws (Inch Series)
ANSI B18.2.2	Square and Hex Nuts (Inch Series)
ANSI S2.19	Mechanical Vibration – Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Unbalance, Including Marine Applications

C. Unit Responsibility:

1. Equipment assemblies made up of two or more components are to be provided as a working unit by the unit responsibility manufacturer, where specified. The unit responsibility manufacturer shall coordinate selection, coordinate design, and shall provide all mechanical equipment assembly components such that all equipment components furnished under the specification for the equipment assembly, and all equipment components specified elsewhere but referenced in the equipment assembly specification, is compatible and operates reliably and properly to achieve the specified performance requirements. Unless otherwise specified, the unit responsibility manufacturer shall be the manufacturer of the driven component equipment in the equipment assembly. The unit responsibility manufacturer is designated in the individual equipment specifications found elsewhere in this project manual. Agents, representatives or other entities that are not a direct division of the driven equipment manufacturing corporation shall not be accepted as a substitute for the driven equipment manufacturer in meeting this requirement. The requirement for unit responsibility shall in no way relieve the Contractor of his responsibility to the Owner for performance of all systems as provided in the General Conditions of the Contract Documents.

2. The Contractor shall ensure that all equipment assemblies provided for the project are products for which unit responsibility has been accepted by the unit responsibility manufacturer(s), where specified. Unit responsibility for related components in a mechanical equipment assembly does not require or obligate the unit responsibility manufacturer to warranty the workmanship or quality of component products not manufactured by them. Where an individual specification requires the Contractor to furnish a certificate from a unit responsibility manufacturer, such certificate shall conform to the content, shall be signed by an officer of the unit responsibility manufacturer's corporation and

shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.

D. Balance:

1. Unless specified otherwise, for all machines 10 HP and greater, all rotating elements in motors, pumps, blowers and centrifugal compressors shall be fully assembled, including coupling hubs, before being statically and dynamically balanced. All rotating elements shall be balanced to the following criteria:

$$U_{per} = 6.015 \frac{GW}{N}$$

Where:

U_{per} = *permissible imbalance, ounce-inches, maximum*

G = *Balance quality grade, millimeters per second*

W = *Weight of the balanced assembly, pounds mass*

N = *Maximum operational speed, rpm*

2. Where specified, balancing reports, demonstrating compliance with this requirement, shall be submitted as product data. Equipment balance quality grade shall be *G* 2.5 (*G* = 2.5 mm/sec) or better in accordance with American National Standards Institute (ANSI) S2.19.

PART 2 PRODUCTS

2.1 FLANGES AND PIPE THREADS

A. Flanges on equipment and appurtenances provided under this section shall conform in dimensions and drilling to ANSI B16.1, Class 125. Pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit.

B. Threaded flanges shall have a standard taper pipe thread conforming to ANSI B1.20.1. Unless otherwise specified, flanges shall be flat faced.

C. Flange assembly bolts shall be heavy pattern, hexagonal head, carbon steel machine bolts with heavy pattern, hot pressed, hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Threads shall be Unified Screw Threads, Standard Coarse Thread Series, Class 2A and 2B, ANSI B1.1.

2.2 BEARINGS

A. Unless otherwise specified, equipment bearings shall be oil or grease lubricated, ball or roller type, designed to withstand the stresses of the service specified. Each bearing shall be rated in accordance with the latest revisions of American Bearing Manufacturers Association (ABMA) Methods of Evaluating Load Ratings of Ball and

Roller Bearings. Unless otherwise specified, equipment bearings shall have a minimum L-10 rating life of 50,000 hours. The rating life shall be determined using the maximum equipment operating speed.

B. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic alemite type.

C. Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 60 degrees C and shall be equipped with a filler pipe and an external level indicator gage.

D. All bearings accessible to touch, and located within seven feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps, fixed ladders or other access structures, shall either incorporate bearing housings with sufficient cooling to maintain surface temperature at 65°C or less for continuous operation at bearing rated load and a 50°C ambient temperature or shall be provided with appropriate shielding shall be provided that will prevent inadvertent human contact.

2.3 NOT USED

2.4 PUMP SHAFT SEALS

A. General:

1. Seals for water and wastewater pump shafts shall be mechanical seals. For industrial wastewater service, or for fluids other than water or municipal wastewater, the recommendations of the seal manufacturer shall be followed for selection of appropriate seals. Unless specified otherwise, mechanical seals shall conform to the requirements set forth in this paragraph.

B. Mechanical Seals:

1. Unless otherwise specified in the detailed pump specifications, mechanical seals shall be split mechanical seals requiring no field assembly, other than assembly around the shaft and insertion into the pump. They shall be self-aligning, and self-centering, single seals. They shall be of a nondestructive (nonfretting) type requiring no wearing sleeve for the shaft. Shafts for pumps specified with mechanical seals shall be furnished with no reduction in size through the seal area (no shaft sleeve). Where the detailed specifications call for cartridge instead of split seals, all other requirements of this paragraph apply.

2. Metal parts shall be Type 316 or 316L stainless steel. Springs shall be Hastelloy C, Elgiloy, or other Duplex SS selected for resistance to chloride attack. Rotary faces shall be silicon carbide or chrome oxide. Stationary faces shall be silicon carbide for solids bearing fluid service and carbon for clean water service.

Elastomers shall be ethylene propylene or fluorocarbon. Mechanical seals shall be suitable for operation between full vacuum (0 pounds per square inch absolute [psia]) up to 200 percent of the maximum specified operating pressure, but in any event not less than 200 pounds per square inch gauge (psig).

3. Seal chambers shall be provided with vented solids removal restriction bushings except for enclosed line shaft pumps where the seal barrier fluid is used for line shaft bearing lubrication. The bushing shall both control the amount of flushing water flow and restrict solids and gas accumulation from the seal face area.

4. Candidate seals include:

   a. Chesterton 442 seals provided with Chesterton/SpiralTrac solids removal restriction bushings Version N or D, as recommended by EnviroSeal Engineering Products, Ltd, Nova Scotia, Canada.

   b. AESSEAL RDS seals with Cyclops bushing.

   c. John Crane 3710 seals with Type 24SL bushing.

5. Seals on pumps for contaminated water service (sludge, grit, wastewater, scum, reclaimed water, etc.) shall be drilled and tapped for connection of a clean water flushing supply.

2.5 COUPLINGS

A. Unless otherwise specified in the particular equipment sections, equipment with a driver greater than ½-horsepower, and where the input shaft of a driven unit is directly connected to the output shaft of the driver, shall have its two shafts connected by a flexible coupling which can accommodate angular misalignment, parallel misalignment and end float, and which cushions shock loads and dampens torsional vibrations. The flexible member shall consist of a tire with synthetic tension members bonded together in rubber. The flexible member shall be attached to flanges by means of clamping rings and cap screws, and the flanges shall be attached to the stub shaft by means of taper lock bushings which shall give the equivalent of a shrunk-on fit. There shall be no metal-to-metal contact between the driver and the driven unit. Each coupling shall be sized and provided as recommended by the coupling manufacturer for the specific application, considering horsepower, speed of rotation, and type of service.

B. Where torque or horsepower capacities of couplings of the foregoing type is exceeded, Thomas-Rex, Falk Steel Flex, or equal, couplings will be acceptable provided they are sized in accordance with the equipment manufacturer's recommendations and sizing data are submitted. They shall be installed in conformance to the coupling manufacturer's instructions.

2.6 GUARDS

A. Exposed moving parts shall be provided with guards which meet all applicable Occupational Safety and Health Administration (OSHA) requirements. Guards shall be fabricated of 14-gage steel, 1/2-13-15 expanded metal screen to provide visual inspection of moving parts without removal of the guard. Guards shall be galvanized after fabrication and shall be designed to be readily removable to facilitate maintenance

of moving parts. Reinforced holes shall be provided. Lube fittings shall be extended through guards.

2.7 CAUTION SIGNS

A. Equipment with guarded moving parts which operates automatically or by remote control shall be identified by signs reading "Caution - Automatic Equipment May Start At Any Time". Signs shall be constructed of fiberglass material, minimum ⅛-inch thick, rigid, suitable for post mounting. Letters shall be white on a red background. The sign size and pattern shall be as shown on the drawings. Signs shall be installed near guarded moving parts.

2.8 GAGE TAPS, TEST PLUGS AND GAGES

A. Gage taps shall be provided on the suction and discharge sides of pumps, blowers and compressors. Pressure and vacuum gages shall be provided where specified. Gage taps, test plugs, and gages shall be as specified in Division 40.

2.9 NAMEPLATES

A. Nameplates shall be provided on each item of equipment and shall contain the specified equipment name or abbreviation and equipment number. Equipment nameplates shall be engraved or stamped stainless steel and fastened to the equipment in an accessible and visible location with stainless steel screws or drive pins.

2.10 LUBRICANTS

A. The Manufacturer shall provide for each item of mechanical equipment a supply of the required lubricant adequate to last through the specified commissioning period. Lubricants shall be of the type recommended by the equipment manufacturer and shall be products of the Owner's current lubricant supplier. The Manufacturer shall limit the various types of lubricants by consolidating them, with the equipment manufacturer's approval, into the least number of different types. Not less than 90 days before the date shown in his construction schedule for starting, testing and adjusting equipment, the Manufacturer shall provide the Owner with three copies of a list showing the required lubricants, after consolidation, for each item of mechanical equipment. The list shall show estimated quantity of lubricant needed for a full year's operation, assuming the equipment will be operating continuously.

2.11 ANCHOR BOLTS

A. Anchor bolts shall be designed for lateral forces for both pullout and shear. Contractor shall determine the size, type, capacity, location, and other placement requirements of anchorage elements. Anchoring methods and leveling criteria in the manufacturer's literature shall be followed. Submit methods and criteria with the Shop Drawings. Unless otherwise stated in the individual equipment specifications, anchor bolt materials shall be Type 316 stainless steel.

2.12 SPARE PARTS

A. Spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified by part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration, such as ferrous metal items and electrical components, shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than two feet wide, or 18 inches high, or three feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

2.13 EQUIPMENT SUPPORTS AND FOUNDATIONS

A. Equipment Supports: Equipment components and supports, anchors, and seismic restrainers shall be adequately designed for static, dynamic, wind, and seismic loads. The design horizontal seismic force shall be the greatest of the following design criteria:
   1. Design Criteria noted in Section 01 60 10 – Design Requirements Non-Structural Components and Non-Building Structures.

B. Submit design calculations for equipment supports, anchors, and seismic restrainers signed and sealed by a licensed professional engineer registered in the State of Utah. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, and normal operation plus wind loadings in accordance with Section 01 60 10 – Design Requirements Non-Structural Components and Non-Building Structures.
   1. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.
   2. Seismic requirements: Freestanding and wall-hung equipment shall be anchored in place by methods that satisfy Section 01 60 10 – Design Requirements Non-Structural Components and Non-Building Structures. Calculations shall be performed and signed and stamped for equipment weighing more that 400 pounds. Calculations shall analyze lateral and overturning forces and shall include a factor of safety against overturning equal to 1.5. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.
   3. Wind requirements: Exterior freestanding equipment shall be anchored in place by methods that satisfy Section 01 60 10 – Design Requirements Non-Structural Components and Non-Building Structures. Calculations shall be performed and signed and stamped, analyzing lateral and overturning forces and shall include a

factor of safety against overturning equal to 1.5. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.

4. Equipment Foundations: Unless otherwise indicated, mechanical equipment, tanks, control cabinets, enclosures, and related equipment shall be mounted on concrete bases per Structural Details S-179 and S-188. Unless otherwise indicated on the Drawings, pumps, blowers, compressors and engine driven equipment shall be provided with a concrete foundation with a total weight equal to at least five times the weight of the equipment. Concrete foundations shall be isolated from the building floor in order to prevent transfer of vibration from the equipment to the building structure. The Contractor through the equipment manufacturer shall verify the size and weight of equipment foundation to insure compatibility with equipment.

5. Equipment Grout: Mechanical equipment installed on top of concrete foundations or bases shall be provided with non-shrink concrete grout as indicated and as specified in Section 03 60 00 - Grouting. Grout shall be applied between the base plate and the concrete foundation or base in accordance with the grout manufacturer's recommendation. Grout shall be free of void space.

PART 3 EXECUTION

3.1 GENERAL

A. Installation of equipment accessories included in this section shall be as recommended by the equipment manufacturer unless otherwise specified in the individual equipment specification section.

END OF SECTION

SECTION 43 11 33
POSITIVE DISPLACEMENT PROCESS BLOWERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Equipment Tag References: 16-B-401

B. Work described in this section includes providing all labor, equipment, materials, tools, and incidentals required for a complete and operable installation of the Rotary Lobe Positive Displacement Blowers system as shown on the Plans and specified herein.

1.2 RELATED SECTIONS

A. Section 01 22 00 – Measurement and Payment

B. Section 01 33 00 – Submittal Procedures

C. Section 01 40 00 – Quality Requirements

D. Section 01 60 00 – Product Requirements

E. Section 01 75 16 – Starting Procedures

F. Section 01 78 23 –Operation and Maintenance Data

G. Division 03 – Concrete

H. Division 26 – Electrical

1.3 REFERENCES

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

1. Section A322: Carbon and Alloy Steel Bar Specifications.

2. Section A507-10: Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold Rolled.

3. Section A48: Standard Specification for Gray Iron Castings

a. American Institute of Steel Construction (AISC) Publications

b. American Welding Society (AWS) Publications

c. American Structures Painting Council (ASPC) Publications

1.4 SUBMITTALS

A. Submittals shall be provided in accordance with Section 01 33 00.

B. Submit copies of all materials required to establish compliance with these specifications for review. Submittals shall include at least the following:

1. A copy of this specification acknowledging compliance or indicating deviation, for every paragraph of this specification. Indicate compliance by a "check" mark in the left-hand margin next to the paragraph. Indicate deviation by a "X" mark. For each deviation, provide an explanation and include supporting documentation to defend the position that the proposed change meets or exceeds the specified requirements. The submittal will not be reviewed without this specification markup. Engineer shall review the deviations as an "or-equal" or "substitution" request, as appropriate, in accordance with the General Conditions. The Engineer retains the right to reject the proposed deviation in favor of the specification as written.

2. Manufacturer's catalog data and shop drawings confirming dimensions, weight, construction, and installation details of blower and all associated equipment.

3. Performance data curves showing the following:

   a. Pressure, capacity, horsepower demand (shaft and line), and compressor efficiency over the entire operating range of blower and all associated equipment.

   b. Pressure, capacity, horsepower demand (shaft and line), and overall efficiency at the guaranteed point, indicated separately.

4. Operating noise levels shall be provided for the blower and for the motor operating together. Noise shall be expressed as sound pressure level in decibels as read on the "A" weighting network of a standard sound level meter (dBA); all measurements shall be made in relation to a reference pressure of 0.0002 microbar.

5. Detailed structural, mechanical, and electrical drawings showing equipment dimensions, sizes, anchor bolt sizes and locations, locations of connections and weights.

6. Factory coatings / finishes.

1.5 OPERATION AND MAINTENANCE MANUALS

A. Submit in accordance with 01 78 23.

B. Manufacturer's standard Operation and Maintenance Manual shall include the following sections:

1. Technical Data for the blower package
2. Safety and Responsibility
3. Design and Function
4. Installation and Operating Conditions
5. Installation
6. Initial Start-up
7. Operation
8. Fault Recognition and Rectification
9. Maintenance
10. Spare parts, Operating Materials, Service
11. Decommissioning, Storage and Transport
12. Appendix with Drawings and Diagrams

1.6 QUALITY ASSURANCE

A. Manufacturer's Qualifications

1. Manufacturer shall have a minimum of five years of experience producing equipment substantially like that required and shall be able to submit documentation of at least fifteen independent installations using the same size or larger equipment as detailed below. Each installation must have been in satisfactory operation for at least five years.

2. The Contract Documents represent the minimum acceptable standards for the equipment. All equipment shall conform fully in every respect to the requirements of the respective parts and sections of the drawings and specifications. The entire unit shall be Manufacturer's standard product, but shall be modified, redesigned, furnished with special features or accessories, made of materials, or provided with finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of the specification.

3. Fabrication shall be done in compliance with all applicable ASTM standards or equivalent international standards.

4. All materials and equipment specified herein shall be within the scope of Underwriter's Laboratories (UL) Examination Services, be approved by the UL for the purpose for which they are used and shall bear an NRTL label.

B. Factory Tests

1. All cast parts to be manufactured in a plant whose quality management system is certified / registered as being in conformity with ISO 9001.

2. All critical dimensions of the blower components provided by the manufacturer shall be verified and documented prior to assembly.

3. Each blower provided by the manufacturer shall be tested per ISO 1217, Annex B.

4. Each blower provided by the manufacturer shall be operated at its maximum rated speed and differential pressure for fifteen (15) minutes.

5. On completion of final assembly of the packaged blower and prior to shipment, each packaged blower shall be mechanically run for a minimum of thirty (30) minutes.

6. Each blower package provided by the manufacturer shall be guaranteed to provide performance to ISO 1217, Annex C.

1.7 WARRANTY

A. Rotary lobe blowers shall be warranted against defects in material and workmanship for a period of 60 months from date of Substantial Completion. All other package components shall be warranted for a minimum period of one year from Substantial Completion.

PART 2 PRODUCTS

2.1 BASIS OF DESIGN

A. Manufacturer used as the basis of design:

1. Aerzen USA Corp. Generation 5 Delta Blower Model GM35S

2. The manufacturer's representative is:

Scott Forsling

Coombs Hopkins Co.

8706 S. 700 East Suite 201 84070

(435) 659-7199

scott@chcwater.com

B. Alternate manufacturers may participate in bidding as “or equals” only if pre-approved. Review as an “or equal” for pre-approval shall be in accordance with the procedures outlined in the General Conditions Article 7.05. Manufacturers listed below (as applicable) must meet or exceed this Technical Specification and related sections.

1. Pre-approved “or-equals” are as follows:

a. None

2. Manufacturers seeking to be listed as pre-approved shall provide a complete submittal for review by ENGINEER a minimum of 15 days prior to bid opening.

C. Substitution requests will not be reviewed during bidding.

2.2 GENERAL

A. The rotary lobe positive displacement blowers provided in this section shall be furnished as a completely assembled, skid-mounted package, including, but not limited to, the blower, motor, V-belt drive, baseplate, inlet air filter/silencer, inlet and discharge silencer, relief valve, flexible connectors, and miscellaneous spare parts and appurtenances.

2.3 SERVICE CONDITIONS

A. Elevation: 4,800 feet above mean sea level

B. Ambient Outdoor Air Temperature: -20° F to 110° F

C. Indoor Building Air temperature: 50° F to 104° F

D. Humidity:

1. Varies from 15% to 70%

2. Design point: 50% at 115° F

2.4 PERFORMANCE REQUIREMENTS

A. Quantity of Machines: 1

B. Design Inlet Pressure: 12.31 psia

C. Design Flow: 750 scfm per machine

D. Minimum Turndown (VFD ONLY): 174 scfm/scfm per machine

E. Design Discharge Pressure: 7.9 psig

F. Maximum Blower Speed: 2968 RPM @ 87% of maximum

G. Brake Horsepower (Max): 47 bHp

H. Motor Size (Max): 60 Hp

I. Free Field Noise Guarantee: 74 dB(A) at 1 meter (at design point)

1. Package BHP to include pressure loss through a clean inlet filter / silencer, pressure loss of the exhaust silencer and check valve.

2. Package Performance shall be guaranteed to ISO 1217 with a tolerance is +/- 5% on volume flow and +/- 5% on package horsepower. Manufacturer of blower must provide data for purchased machine.

3. Sound data shall be from an ISO 2151 method of measurement, in an ISO 3745 qualified test facility. Sound data shall be compliant with a Declaration of Conformity assessment standard.

2.5 EQUIPMENT DESCRIPTION

A. General

1. Blowers shall be rotary lobe, dynamically and statically balanced, tri-lobe design with piped inlets and outlets and channels integrated on the discharge to reduce blower pulsation and dampen noise.

2. Blowers and appurtenances shall be supplied by a blower manufacturer with a Quality Control System certified in accordance with ISO 9001. Units shall be furnished as a complete system.

B. Blower Package Configuration:

1. Installation Location: inside

2. Inlet Configuration: piped from interior ducting to each individual blower.

3. All components and instrumentation are to be mounted and pre-piped; no field installation shall be required by the contractor. The manufacturer shall be responsible for all aspects of the engineering, from the blower package's air inlet to its discharge connection.

C. Housing

1. The blower casing shall be of one-piece construction, with separate side plates that are bolted and pinned to the housing.

2. Materials shall be close-grained cast iron suitably ribbed to prevent distortion under the specified operating conditions.

3. Minimum blower casing pressure rating shall be 36 psig.

4. Inlet and outlet shall be flanged connections.

5. The casing shall incorporate a proven means of pulsation cancellation which achieves 90% of better reduction in vibration. Systems without a means of pulsation cancellation shall not be accepted.

6. The vibration level as measured at the blower casing, in the X/Y planes of the bearings, shall not exceed ½ "/ sec RMS when operating at the specified maximum operating pressure and speed in the actual blower package.

D. Rotors

1. Each rotor shall be of the "stiff" design with first lateral critical speed at least 120% of the maximum allowable operating speed.

2. The rotors shall be of the straight, three-lobe type, and shall operate without rubbing or liquid seals or lubrication.

3. Rotor/shaft shall be one single piece. Cast, hollow rotors shall be capped, dust tight. Open rotors are not acceptable.

4. The rotors shall be statically and dynamically balanced per ISO1940/ANSI S2.19 G6.3.

E. Timing Gears

1. The rotors shall be timed by a pair of single helical AGMA 12 quality gears with hardened and ground teeth; minimum AGMA service factor of 1.70. Spur cut gears are unacceptable

2. Gears shall be mounted on the shafts with a tapered interference fit and secured by a locknut. Pinned gears are unacceptable.

F. Seals:

1. Seal shall be designed to prevent lubricant from leaking into the air stream as well as to prevent oil from leaking out of the machine.

2. Four rotary piston ring shaft seals, an oil slinger and an O-ring seal shall be provided at the point where the shaft passes through the side plates.

3. Further provision shall be made to vent the rotor side of the oil seal to atmosphere to eliminate any possible carry-over of lubricant into the air stream.

G. Bearings

1. Each rotor/shaft shall be supported by anti-friction bearings and fixed to control the axial location of the rotor/shaft in the unit.

2. Regardless of theoretical bearing life calculations, the bearings shall be sized for a minimum expected life of 5 years between overhauls. Calculated bearing life shall be submitted, based on specified operating conditions.

H. Lubrication

1. Both the gear end and the drive end of the blowers shall be oil splash lubricated via a disc slinger for minimal maintenance and long service life. Grease lubricated bearings in the blower are not acceptable.

2. The lubrication design shall provide adequate lubrication of the timing gears and bearings.

3. The drive-end and gear-end oil chambers must not be interconnected, and each oil chamber shall allow visual inspection of oil level and oil condition, viewable from the exterior of the blower.

4. Blower to be factory filled with a synthetic lubricating fluid that is rated for the design conditions specified.

I. Oil Sight Glass:

1. A recessed oil sight glass must be provided on each oil sump.

2. Protruding sight glasses shall not be acceptable.

J. Flexible Connectors:

1. Each package shall be connected to the plant piping via flexible connector(s) located downstream of the discharge silencer and upstream of the inlet silencer.

2. Flexible connectors shall prevent the transmission of noise and vibrations from the blower package into the piping.

3. Flexible inlet connectors shall be a reinforced silicone sleeve secured by four (4) stainless steel clamps and terminating with a standard epoxy coated steel ANSI flange connection. (By vendor)

4. Flexible discharge connectors shall be Proco Style 240, Type EE, EPDM, with a standard ANSI flange discharge connection, rated for 300 °F at 20 psig. (By contractor)

K. Local Control Panel:

1. Each package shall be supplied with the following control functions and features:

a. Intuitive TFT color touch screen display

b. Display, monitoring, alarm, and shutdown of inlet pressure, discharge pressure, discharge temperature, drive motor thermal overload.

c. Display run hours

d. Log errors and first out indication

e. Track and log maintenance

f. E-Stop button mounted on front of blower enclosure

g. Operation of enclosure cooling fan motor starter and oil demister

h. Ability to transfer measured values, fault and status messages, as well as remaining times of the service intervals to the customer control system via Ethernet IP. Controllers that use a non-industrial protocols such as CAN shall not be allowed.

i. Permissive control function of customer start and stop signals to a motor controller

j. Digital potentiometer

i. LOCAL Operation: speed control of the VFD via the HMI screen.

ii. REMOTE Operation: transfer of VFD speed command from external controller to the VFD

iii. These signals can be communicated using either hard wire connection or the communication protocol

k. The local control panel shall be provided with the following digital outputs:

i. Common alarm

ii. Common fault

iii. Ready to run

iv. Transfer of external start/stop command

v. Status remote

vi. Maintenance required

vii. Alternatively, these outputs can be obtained using the communication protocol

l. The local control panel shall be provided with the following digital inputs:

i. Remote start/stop

ii. Motor controller fault

iii. Customer E-stop

iv. Alternatively, these inputs can be supplied using the communication protocol

2. Control Enclosure

a. IP54 (2.0) for indoor installation

b. Factory installed, integral to sound enclosure

3. Control Supply Power

a. 110 VAC, 10 Amp feed with 24 VDC transformer

4. Monitoring Sensors

a. Inlet Pressure Transducer

b. Discharge Pressure Transducer

c. PT 1,000 Discharge Temperature RTD

5. Local control panel shall be the Aerzen AERtronic Digital Controller

2.6 MOTORS

A. Electric Motor:

1. Each package shall be supplied with a WEG manufactured TEFC motor that shall operate on 460 Volts, 3 Phase, 60 Hertz current, 1800 RPM.

a. Torque NEMA B

b. Temperature Rise Class B

c. Dust tight enclosures (Severe Duty)

d. Class F inverter rated insulation with Class H applied varnish

e. 3:1 constant torque

f. All cast iron construction, including frame, end bells, conduit box and fan cover

g. NPT threaded and gasketed F3 top mounted conduit box

h. Copper windings

i. Regreasable bearings, positive pressure lubrication system with automatic drawn plugs – pressure compensated (Frame sizes 254T and larger).

2. All frame sizes shall be NEMA standard, suitable for overhung belt drive and with the conduit box location on top of the motor. IEC frame motors shall not be allowed.

3. The motor shall be mounted on a pivoting base to provide automatic tensioning of the belts.

4. The motor nominal rating after any corrections for ambient conditions shall be 10% above the maximum operating bHp.

5. The motor shall have a 1.15 service factor.

6. Motor windings shall be supplied with a normally closed thermostat, one per phase, wired in series to form a fail-safe motor protection circuit for the external fault circuit of the motor controller.

7. If the motor is VFD driven, the motors shall be equipped with an Aegis ring to mitigate the effects of stray motor currents.

8. Blower manufacturer shall be responsible for coordinating the starting torque requirement of the blower and the motor.

B. Variable Frequency Drive:

1. The VFD shall be a Danfoss Aqua VFD.

2. Each blower package shall include a factory mounted, 6-pulse, constant torque, variable frequency drive.

3. Drive shall operate on 460 VAC, 3 phase, 60 hertz power and shall be integrated with the local blower permissive switches.

4. The drive shall include the following features and accessories:

a. NEMA 12 enclosure for indoor installation

b. Rotary fused disconnect

c. Method to minimize power line harmonics while providing a near unity power factor.

d. Input surge protection to withstand surges of 2.3 times line voltage for 1.5 msec.

e. Ethernet IP communication over CAT5 cable

f. Minimum 100kA SCCR safety rating

5. The VFD shall have the following local indicators with local reset

a. E-Stop

b. Inlet Pressure High

c. Discharge Pressure High

d. Motor Over Temp

e. Blower Over Temp

2.7 BLOWER PACKAGE

A. Each blower shall receive its initial oil filling at the factory, the synthetic oil shall be rated for a minimum of 16,000 hrs.

B. Drive

1. Each package shall be supplied with a V-belt drive that shall be of the high-capacity type, oil and heat resistant. Drive shall be designed for a minimum service factor of 1.4 times operating power (bHp), or 1.1 times the motor nameplate Hp, whichever is larger to allow a minimum of 1.4-service factor based on the maximum blower bHp.

2. Belt tensioning shall be automatic without the use of any devices or interaction on the part of the operator. Neither slide rails nor load-adjusting springs shall be used.

3. Sheaves shall be dynamically balanced regardless of the operating speed.

4. The blower drive must have a fully enclosed guard which protects the operator when the blower package enclosure is open while in operation.

a. The belt drive shall be guarded in compliance with OSHA regulations.

b. Portions of the guard shall be easily removable allowing for belt inspection and replacement.

c. Guard material shall be perforated carbon steel.

C. Inlet Silencer

1. An inlet silencer designed for the frequency range of the blower, shall be provided to reduce the noise of the blower package as specified.

a. The silencer shall be located upstream of the inlet filter.

b. Silencer performance losses shall be included in the blower performance calculation.

c. The filter element shall be designed to trap dirt on the inside so that upon changing, dirt does not fall into the machinery. Filters where dirt accumulates on the external surface of the filter will not be permitted.

D. Base frame with integrated discharge silencer:

1. The blower base frame with integrated discharge silencer shall be designed for the frequency range of the blower, shall be provided to reduce the noise of the blower package as specified.

    a. The silencer shall have a machined inlet connection where the discharge flange of the blower stage bolts directly to, with no intermediary pieces. Threaded connection between the compressor stage and the discharge silencer is subject to leakage and misalignment and will not be permitted.

    b. The base frame shall be constructed from welded carbon steel or cast iron that shall be designed to maintain alignment of the blower internal components and the drive during operation.

    c. The base frame shall be designed to resist distortion while being installed on vibration isolating mounts.

    d. The blower manufacturer shall supply a stainless-steel grounding lug fully welded to the base.

    e. The discharge silencer shall be an integral part of the base frame.

    f. The silencer shall be fabricated of a single shell of pressure vessel quality steel with continuous welds.

    g. The silencer shall be a chamber type design for maximum sound attenuation and shall not use fibrous or absorption materials of any kind. Internal absorption material has been shown to degrade and internally foul diffusers and will not be permitted.

    h. Discharge silencer performance losses shall be included by the blower vendor in the blower performance calculation. This is another reason why the blower accessories must be supplied by the manufacturer of the blower stage.

E. Blower Sound Enclosure:

1. Each package shall be supplied with a sound enclosure covering the entire blower package.

2. The enclosure shall provide suitable protection for outdoor installation under the specified site conditions (wind load and snow load).

3. The enclosure shall be designed so as to be able to install them side-by-side with all maintenance done from the front or back of the package.

4. Details shall be as follows:

a. Panels shall be made of galvanized steel sheet, powder coated in a light reflecting, blue color per RAL 5001. The skid shall be of the same color.

b. The enclosure and the blower package shall both be mounted on a skid / oil-drip pan designed for meeting environment protection standards and for easy transportation and installation.

c. A grounding strap shall be installed between the blower base and the package skid to bypass any vibration isolating mounts.

d. Quick release panels, each less than 50 lb (as mandated by MSHA) must provide easy and quick access for routine maintenance of the blower and the package components.

F. Enclosure Cooling Fan:

1. A high efficiency blower shaft driven ventilation fan shall provide ventilation and cooling integral to the sound enclosure.

2. Cooling fan shall be sized for sufficient heat removal from the sound enclosure, even when the blower is operated with a VFD.

a. Electrical components, instrumentation and instrument connections shall not be mounted or interface with moving panels of the sound enclosure.

b. Both blower oil sumps shall be piped to a common fill and drain, located at the front of the package for easy maintenance. An oil level indicator shall be mounted on the outside of the enclosure, which gives an accurate oil level indication while the blower is in operation. All oil lines to be hydraulic hose with fittings. No plastic tubing with compression fittings is allowed.

2.8 INSTRUMENTATION AND CONTROLS

A. Each Blower shall be furnished with an instrumentation terminal junction box within the blower enclosure. The junction box shall be NEMA 12, size as required by manufacturer. A terminal strip shall be provided inside of the junction box with all instrumentation associated with the blower terminated and pre-wired by the manufacturer for a single point of connection by the Contractor.

B. The following instrumentation and all associated relays and terminals shall be pre-wired by the manufacturer to the provided terminal strip for each of the blower enclosures.

1. Blower Motor Over Temperature PTC Thermistors

2. Blower Enclosure Over Temperature Switch.

3. Blower Discharge Air Over Temperature Switch.

C. All Blower mounted devices shall be furnished with nameplates that are engraved to represent the function and/or ISA numbering, as shown on the drawings, and shall be UL listed, or equivalent

2.9 ACCESSORIES

A. Pressure Relief Valve

1. The pressure relief valve shall be housed by the sound enclosure and shall relieve into a segmented section of the sound enclosure. Weighted relief valves inside in the enclosure are not permitted.

B. Check Valve

1. Each package shall be supplied with one check valve that shall be installed on the discharge line.

2. The check valve shall be of the full-bore low pressure-drop, flapper type design with a steel body, and steel flap embedded in EPDM with full-contact seal.

3. The valve shall be removable without disturbing the piping. Pressure losses produced by the check valve shall be included in the blower performance calculation. Check valves requiring installation in the discharge piping shall not be considered unless installation cost of the external valve is included in supplier's proposal.

4. The valve shall be manufactured by Aerzen.

a. Terminal Strip

i. The switches and motor thermostat shall be prewired to a labeled terminal junction box inside the blower enclosure.

C. Vibration isolators

1. Each package shall be supplied with vibration isolating feet with a minimum efficiency of 80%.

2. Blower manufacture shall be responsible for attenuating noise and vibration in the blower package such that no special installation base shall be required, nor shall any additional measures be required to

reduce vibrations from the blower package being transmitted to the base or the piping.

D. Pressure Relief Valve

1. Each package shall be supplied with a single pressure safety valve on the discharge side of the blower mounted downstream of the discharge silencer and upstream of the check valve.

2. The safety valve shall be set to protect the blower from exceeding its maximum pressure rating and shall be sized to pass 100% of the design flow.

3. The safety valve shall be field adjustable, spring loaded, and have a certificate of conformity to PED.

4. If the blower package is supplied with a sound enclosure. The pressure relief valve shall be housed by the sound enclosure and shall relieve into a segmented section of the sound enclosure. Weighted relief valves inside in the enclosure are not permitted.

5. The valve shall be manufactured by Aerzen.

E. Other Accessories

1. Vibration isolation pads

2. Butterfly valves as shown on the Drawings (provided by Contractor)

2.10 SPARE PARTS AND SPECIAL TOOLS

A. The following spare parts shall be furnished for each unit:

1. Two integral inlet silencer filter elements

2. Lubrication for first year of operation

3. One belt set

4. One tube of motor grease

B. The Contractor shall furnish one set of special tools required for maintenance, if applicable.

2.11 FINISHING

A. Painting shall be per supplier's standard meeting the following criteria:

1. Except for machined sealing and machined mounting surfaces, the package shall be painted dark blue.

2. Aluminum, stainless steel, and brass shall not be painted.

3. The supplied motor shall not be over sprayed and will be supplied with the motor manufacturer's standard protection and paint color.

4. Painted Cast Iron and Carbon Steel shall be Alkyd Resin Primer and Final coat with a total dry film thickness of 70μm. Surface preparation SSPC10 or better.

5. Sound enclosure shall be powder-coated polyester base total dry film thickness 80μm.

6. Galvanized components shall only be painted with appropriate surface preparation

PART 3 EXECUTION

3.1 PRODUCT DELIVERY, HANDLING AND STORAGE

A. Delivery and Handling of Equipment:

1. Manufacturer and Contractor shall coordinate the delivery schedule for the project schedule.

2. Contractor shall unload and inspect all equipment and materials against reviewed shop drawings at the time of delivery. Any damage shall be reported to the freight company immediately upon receipt.

3. Equipment and materials damaged or not meeting the requirements of the reviewed shop drawings shall be immediately returned for replacement or repair.

4. Each box or shipping crate shall be properly marked to show its net weight and its contents.

B. Storage:

1. Contractor shall prepare for storage and label all equipment and materials after they have been inspected. The Contractor shall be responsible for the equipment and materials while in storage.

2. Store materials to permit easy access for inspection and identification.

3. Support all material off the ground while protecting steel members and packaged material from corrosion and deterioration as per manufacturers' instructions.

3.2 EXAMINATION

A. Verify all equipment and materials are present and meet the requirements of these Specifications.

3.3 INSTALLATION

A. Installing Contractor shall install the equipment specified herein in accordance with the Manufacturer's requirements. Vendor shall provide assistance and clarification as required during installation. Contractor responsibilities are generally as follows:

1. The Contractor will be responsible for reviewing the design of the equipment provided by the manufacturer, so that it fits properly in the structure and interfaces properly with associated equipment provided by others.

2. The Contractor will be responsible for receiving the equipment, unloading it from the common carrier, and storing it safely until it is ready to be installed.

3. The Contractor will install the manufacturer's equipment in accordance with the manufacturer's Installation, Operation and Maintenance instructions.

4. The Contractor will provide all field wiring between the electrical devices on equipment and the control panel. Contractor will also provide all required local disconnects and junction boxes.

5. The Contractor will provide all field piping, fittings, isolation valves, and related components required to connect to vendor's equipment.

B. After the equipment is installed, the vendor shall provide a factory trained, experienced, competent, and authorized representative to inspect the installation, generate a deficiency list for the Installing Contractor, and perform on-site commissioning with the assistance of the Installing Contractor.

C. Vendor's representative shall provide a minimum of two days (8 hours on-site per day minimum) of on-site installation inspection and assistance. If additional time is required to assist with the installation, it shall be at no additional cost to the Owner.

3.4 LUBRICANTS AND LUBRICATION SERVICES

A. The Contractor shall lubricate the mechanical equipment prior to initial operation.

B. The Contractor shall be responsible for completing the first scheduled lubrication services after the equipment has undergone the initial break-in period according to the manufacturer's recommendations for stated run-time hours.

3.5 COORDINATION OF RELATED EQUIPMENT

A. Contractor shall carefully coordinate equipment, motors, drives, and controllers so that the completed system operates satisfactorily under all operating conditions.

3.6 FIELD QUALITY CONTROL

A. Initial Starting and Testing of Systems

1. Vendor's representative shall provide a minimum of one day (8 hours on-site per day minimum) of on-site assistance for initial starting and testing of systems. If additional time is required to assist with the initial starting and testing of systems, it shall be at no additional cost to the Owner.

2. Conduct performance testing on each blower unit to verify that the operating range satisfies the specifications. Each blower shall be operated at the minimum, maximum, and design speeds. Record operating conditions at each point, including the following as a minimum: discharge pressure, amperage, ambient air temperature and humidity, air flow, blower temperature (casing and enclosure).

3. Record sound levels at three feet from the blower to verify sound attenuation specifications are satisfied.

4. Initial starting and testing of the blowers shall occur after the new diffusers in Treatment Basin No. 2 are installed and ready for operation.

B. Acceptance Testing

1. Seller's representative shall provide a minimum of one day (8 hours on-site per day minimum) of on-site support for acceptance testing.

2. Acceptance testing shall be completed with the treatment basins in service with MLSS concentrations at 6,000 mg/L minimum.

3. The blowers shall be field tested in the presence of the Engineer to verify that operation is satisfactory and in compliance with the Specification.

C. If the blower package does not meet the requirements of this Specification, corrective measures shall be taken, and re-testing undertaken to confirm compliance with the Contract Documents at no cost to Owner.

3.7 COMMISSIONING EQUIPMENT

A. Perform initial testing, training, and commissioning per Section 01 65 00.

3.8 TRAINING

A. Vendor's qualified service representative shall provide a minimum of one day (8 hours on-site per day minimum) of training of the Buyer's staff for operation and maintenance of the equipment.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 43 12 10
POSITIVE DISPLACEMENT SOLIDS HANDLING BLOWERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section covers the work necessary to furnish and install positive displacement blowers, motors, and related equipment.

1. Process Solids Handling Blowers: 80-B-110 and 80-B-111

1.2 RELATED SECTIONS

A. Section 01 20 00 – Measurement and Payment

B. Section 01 33 00 – Submittal Procedures

C. Section 01 40 00 – Quality Assurance and Quality Control

D. Section 01 65 00 – Commissioning of Systems

E. Section 01 73 00 – Installations, Operation, and Maintenance Manuals

F. Division 3 – Concrete

G. Section 09 90 00 – High Performance Coatings

H. Division 26 – Electrical

I. Section 46 51 21 – Coarse Bubble Diffuser Aeration System

1.3 SUBMITTALS

A. Submittals shall be provided in accordance with Section 01 33 00, Submittal Procedures. The following information shall be provided:

1. Manufacturer's Certificate: Certify that products meet or exceed specified requirements and are suitable for the use intended. Motors specified for variable speed operation through a variable frequency controller shall be capable of operating at low reduced speed for extended periods of time without overheating and can operate without excessive vibrations or harmonies at any speed.

2. Manufacturer's catalog data and shop drawings confirming dimensions, weight, construction, and installation details of blower and all associated equipment.

3. Performance data curves showing the following:

   a. Pressure, capacity, horsepower demand, and compressor efficiency over the entire operating range of blower and all associated equipment; and

   b. Indicating separately the pressure, capacity, horsepower demand, and overall efficiency at the guarantee point.

4. Operating noise levels shall be provided for the blower and for the motor operating together. Noise shall be expressed as sound pressure level in decibels as read on the "A" weighting network of a standard sound level meter (dBA); all measurements shall be made in relation to a reference pressure of 0.0002 microbar.

5. Detailed structural, mechanical, and electrical drawings showing equipment dimensions, sizes, locations of connections and weights.

6. Factory finish system.

7. Provide written copies of manufacturer's warranties on products described in this specification section.

8. Provide Equipment Operation and Maintenance Manuals to the Owner per Section 01 73 00.

9. Submit a copy of this specification section, with addendum updates included, with each paragraph clearly marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. If deviations from the specifications are indicated and therefore requested by the Contractor, the submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification for any requested deviations to the specification requirements, with the submittal shall be cause for rejection of the entire submittal with no further consideration. The Owner retains the right to reject any proposed deviations in favor of this specification, as written.

1.4 QUALITY ASSURANCE

A. Like items of equipment specified herein shall be the end products of one manufacturer in order to achieve standardization of appearance, performance, operation, maintenance, spare parts, and manufacturer's service. Packaged units supplied by blower packagers are not allowed, and units supplied shall be from a single manufacturer.

B. The Manufacturer must be regularly engaged in the design and manufacture of similar equipment for a minimum of ten years.

1.5 WARRANTY

A. The Blower installed in the Package shall be warranted to be free from defects in materials and defects in workmanship for a period of five years from the date the Manufacturer's Representative certifies the installation.

B. All other Packaged Blower components shall be warranted to be free of defects in material and defects in workmanship for a period of one year from the date the Manufacturer's Representative certifies the installation.

1.6 MANUFACTURER'S SERVICES

A. The contractor shall provide a manufacturer's representative for the equipment specified herein for the person-days listed for the services hereunder, travel time excluded:

1. ½ person-day for functional testing, certification of the installation with written documentation, and plant startup.
2. ½ person-day for training.

B. Refer to specification section 01 65 00 Commissioning of Systems for additional requirements.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Manufacturers: Provide positive displacement blowers with integrated control panel meeting the requirements of this specification from one of the following manufacturers. Manufacturers meeting the requirements of this specification but not listed here may be considered in accordance with the Contract Documents and the Instructions to Bidders.

1. Aerzen USA, Coatesville, Pennsylvania.
2. Kaeser Compressors, Fredericksburg, Virginia.
3. Or approved equal.

2.2 GENERAL

A. The rotary positive displacement blowers provided in this section shall be furnished as a completely assembled, skid-mounted package, including, but not limited to, the blower, motor, on-board microprocessor-based control panel and integrated variable frequency drive (VFD), V-belt drive, baseplate, inlet air filter/silencer, inlet and discharge silencer, relief valve, flexible connectors, and miscellaneous spare parts and appurtenances. All components are to be mounted, piped, and wired requiring only a single point electrical connection for power and single point piping connections for inlet and discharge air.

2.3 SERVICE CONDITIONS

A. Elevation: 4,810 feet above mean sea level.

B. Ambient Temperature: -20°F to 104°F.

1. A temperature of 104°F shall be used to determine blower and motor requirements.

C. Humidity. 15 percent to 80 percent.

1. A humidity of 80 percent shall be used to determine blower and motor requirements.

2.4 PERFORMANCE REQUIREMENTS

A. Solids handling process blowers (80-B-110 and 80-B-111) shall be designed for the following operating conditions:

Quantity of blowers	2 (1 duty, 1 standby)
Motor Rated Power (maximum, per blower)	100 hp
Maximum Free Field Noise Pressure @ 3 Ft	70 dB(A)
Design Inlet Temperature	104 °F
Site Elevation	4810 ft
Design Relative Humidity	80%
Design Point	
Minimum air flow (per blower)	525 scfm
Design air flow (per blower)	1272 scfm
Discharge pressure	7.40 psig

B. Final scfm and hp requirements for the blowers to be coordinated with diffuser supplier prior to submittal.

C. Each blower shall be equipped with an on-board control panel. Controls and Instrumentation shall be in accordance with the P&IDs and Division 40 specifications.

D. A variable frequency drive (VFD) will be furnished and installed by the CM/GC on the side of the blower unit so the air capacity can be adjusted to meet the demands of the process via analog input signal from the supervisory control and data acquisition (SCADA) system and networked to the plant SCADA system.

E. Factory calculated free field sound pressure levels for each blower and motor combination shall be measured in accordance with American National Standards Institute (ANSI) S51, latest edition.

F. Each blower shall meet the rated performance and sound level when operating at a maximum gear tip speed of 4,500 feet per minute.

G. Blower casing and components shall be designed and tested to supply up to a 13.0 pounds per square inch gauge (psig)pressure rise.

H. Blower shall be designed to deliver air free of contaminating lubricants and shall be compatible with the coarse bubble membrane (EPDM) type diffused air systems.

I. Blower shall be selected so as not to exceed 85 percent of its maximum speed rating.

2.5 EQUIPMENT DESCRIPTION

A. General

1. Blowers shall be rotary lobe, dynamically and statically balanced, tri-lobe design with an equalization chamber integral to the blower housing. With the combination of three lobes and the “equalization” chamber the pulsations are greatly reduced by the principle of wave interference resulting in a 20 to 35 dB attenuation of the fundamental frequency.

2. Blowers and appurtenances shall be supplied by a blower manufacturer with a Quality Control System certified in accordance with ISO 9001. Units shall be furnished as a complete system.

B. Housing

1. Close grained, high strength cast iron construction with DIN inlet and outlet connections. An adapter can be provided for transition from DIN to National Pipe Thread (NPT) or ANSI flange as required.

2. Adequately ribbed to prevent distortion.

3. Provided with a built-in "equalization" chamber.

4. Drive end head-plate is integral to the casing.

C. Rotors

1. Stiff-shaft design with the first lateral critical speed shall be at least 120 percent of the maximum allowable speed.

2. Any torsional natural frequency shall be at least 10 percent above or 10 percent below the operating speed range of the blower.

3. The rotor and shaft assembly shall be a one-piece design constructed of ductile iron.

4. Rotors shall be solid or have closed ends.

5. Rotors shall have an integral sealing strip for improved efficiency.

D. Timing Gears

1. Spur type, AGMA Grade 12 equivalent quality with minimum service factor of 1.7 at the maximum operating point.

2. Gears shall be secured by an interference fit on ground tapered shaft ends.

E. Bearings

1. Type: Cylindrical Roller Bearings.

2. L-10 Life of at least 80,000 hours under constant maximum load.

3. Bearings and gears shall be splash lubricated.

F. Seals at Rotor Chamber

1. Non-rubbing, vented labyrinth seals each containing four (4) hardened steel piston rings, oil deflector, and grooved, multiple labyrinth bushing. There are a total of sixteen (16) piston ring seals.

2. Any lip seal inside the machine is not acceptable.

G. Blower Package: The packaged blowers are to be standard engineered designs of a CE certified manufacturer regularly engaged in the production of packaged blowers to ensure single source accountability and shall include the following listed standard features:

1. The packages shall be driven through V-belts and sheaves. The drive assembly shall be of the high capacity type, oil, and heat resistant, with a minimum service factor of 1.5.

2. Automatic tensioning of the V-belts by use of a pivoting, swing frame motor base with adjustable spring assistance and visual indication of V-belt tension shall be provided to ensure the V-belts remain properly tensioned with minimal maintenance and to extend V-belt, sheave, and bearing life. Adjustment of the tensioning device shall be accomplished without removal of the guard or loosening of the motor mounting bolts.

3. The drive guard shall be the manufacturer's standard sheet metal with provision for ventilation. The installed guard shall be fully enclosed, easily removable, and designed to meet current Occupational Safety and Health Administration (OSHA) recommendations and CE standards.

4. The base shall be an elevated, rigid, fabricated steel design with a solid sub-base. The absorptive type discharge silencer shall be integral to the frame in order to minimize space requirements. The blower shall be mounted horizontally for a compact frame.

5. To prevent transmission of vibration and noise, as well as secure the package to the foundation, the base shall include vibration isolators made of rubber in a steel footing equipped with mounting holes for anchoring purposes.

6. Oil drains from the blower drive-end and gear-end lubricating oil sumps shall be piped to the front of the base for ease of maintenance. The drain valves shall be a ball valve with a fully retained and gasketed threaded cap.

7. The inlet filter shall be integral to the inlet silencer and shall include a washable and reusable polyester element for minimal pressure drop.

8. The inlet air filter/silencer shall be of the absorptive type with tube connection for a piped inlet and shall draw air from outside the building. The inlet air filter shall be capable of supplying air to the blower at its maximum rated capacity with a clean pressure drop no greater than three inches water column.

9. The discharge silencer shall be of the absorptive type with an integral pulsation dampener and directly connected to the outlet port of the blower. The discharge silencer shall be mounted horizontally and shall be integral to the

base frame. Pressure loss through the silencer at the discharge flow rate shall be less than six inches water column.

10. The relief valve shall be spring loaded, and factory installed in a location to protect the blower from excessive differential pressures. The relief valve exhaust shall be piped out of the enclosure. The safety relief valve shall be field adjustable and initially set at 8.4 psig.

11. An elastomeric compensator/flex connector shall be provided for connection of the packaged blower to the system piping to reduce transmission of structure borne noise as well as prevent unacceptable loading of the silencer connection and blower casing. The flexible connector shall be rated for 350°F operating temperature.

12. A sound enclosure shall be provided. The sound enclosure shall be sheet steel construction with powder coat finish. It shall have acoustic foam insulation and shall provide sound attenuation of up to 20 dB(A). The enclosure shall have a hinged panel on top and a removable panel on the front of the package to allow maintenance access. Panels shall incorporate locking closures. An installed, integral ventilation fan, sized to provide adequate cooling of the package, shall be provided.

13. An instrument panel shall monitor inlet pressure, inlet temperature, discharge temperature, discharge pressure, filter differential, enclosure temperature, emergency stop, and motor overloads (motors and fans).

14. The blower package shall be designed to allow all preventive maintenance to be performed from the front of the package. All utility connections and process connections shall be at the rear of the package.

15. The blower package shall be capable of being installed directly adjacent to another blower packages of similar design and shall be capable of mounting next to the wall without maintenance interference.

H. Discharge Piping

1. Pipe insulation shall be installed, for each unit, for all discharge piping inside the building, from blower connection to building outlet.

2.6 MOTORS

A. General

1. Refer to Division 26 for the basic requirements that apply to the motors supplied under this section.

B. Motor Type

1. Blower motors shall be WEG manufactured TEFC, 230/460 VAC, 3-phase, 60-hertz, meeting or exceeding Energy Independence and Security Act (EISA) 2007 standards for motor efficiency.

2. All frame sizes shall be NEMA standard, suitable for overhung belt drive and with the conduit box location on top of the motor. IEC frame motors shall not be allowed.

3. 1.15 Service Factor.

4. Supplied, mounted and aligned by the blower package supplier.

5. The motor nameplate horsepower rating shall not be exceeded at any point on the operating curve.

6. Duty cycle continuous.

7. Inverter duty, compatible with variable frequency drive service.

2.7 ACCESSORIES

A. Equipment Identification Plate. A 16-gauge, stainless steel identification plate shall be securely mounted on the equipment in a readily visible location. The plate shall bear, in ¼-inch die-stamped lettering, the equipment identification name and number indicated in this specification.
   1. Refer to specification section 43 05 10 Equipment General Provisions.

B. Lifting Lugs. Equipment weighing over 100 pounds.

C. Anchor Bolts. ASTM A193, Type 316 stainless steel, sized by equipment manufacturer, ½-inch diameter minimum. Anchor bolts shall be supplied by Contractor.

D. Other Accessories

   1. Check valve–Technocheck Model 5050 with viton elastomers, or equal suitable to 350°F air service

   2. Inlet Filter/Silencer for outdoor air intakes:

      a. Connection: Flanged, 125/150# ANSI. Size as shown on Drawings

      b. Element: Stainless Steel

      c. Pressure Drop: <0.2 psig at maximum rated flow

      d. Finish: Epoxy or Baked-On Enamel Coating for Outdoor Use

      e. Operating Temperature: -20°F to 105°F

      f. Manufacturer: Endustra P09

2.8 BLOWER PACKAGE CONTROL PANEL

A. It is intended that each blower package will include all of the instrumentation, safeties, and controls necessary to protect the Blower and the operators.

B. Each Blower Package shall include an integrated controller to process and transmit signals to/from the blower unit instrumentation and to/from the plant SCADA system. The controller shall include an OIT with an integrated keypad and display.

C. The Blower Package Control Panel shall include an Emergency Stop button and a digital analog readouts of the monitored pressures and temperatures.

D. Provide integral terminal block for ease of connection for plant SCADA monitoring/control instrumentation as indicated on the P&IDs.

E. The Blower Package Control Panel shall permit local start/stop of the individual Packaged Blower as well as remote start/stop.

F. Each Blower Package shall include speed monitoring to provide feedback to the integrated controller/SCADA system regarding system flow.

G. The Packaged Blower Control shall include, as a minimum, the following listed functions:

1. Maintenance Interval Alarm
2. Filter Differential Alarm
3. Inlet Temperature Alarm
4. Emergency Stop Shutdown
5. Frequency Control Fault Shutdown
6. Blower Discharge Pressure Shutdown
7. Blower Pressure Rise Shutdown
8. Blower Discharge Temperature Shutdown
9. Blower Temperature Rise Shutdown
10. Loss of Analog Input Shutdown
11. Enclosure Air Temperature Shutdown

2.9 SPARE PARTS AND SPECIAL TOOLS

A. The following spare parts shall be furnished for each unit:

Item	Quantity
Oil	Sufficient for first two oil changes
V-belts	1 set
Inlet Filter Elements	1 set

B. The Manufacturer shall furnish one (1) set of special tools required for maintenance.

2.10 FINISHING

A. Provide blower units with the manufacturer's standard factory finish.

PART 3 EXECUTION

3.1 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. Align, adjust, and lubricate in accordance with the manufacturer's instructions and leave in proper working condition.

3.2 FIELD QUALITY CONTROL

A. Functional Tests

1. Alignment. Prior to facility startup, test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.

B. Performance Test

1. Conduct on each unit to verify operating range satisfies the specifications.

END OF SECTION

SECTION 43 23 58

ROTARY LOBE DEWATERING FEED PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Rotary lobe pumps for dewatering feed pumping from biosolids holding tank to dewatering equipment.

B. Equipment Tag References: 80-P-201 and 80-P-202

1.2 RELATED SECTIONS

A. Section 01 20 00 – Measurement and Payment

B. Section 01 33 00 – Submittal Procedures

C. Section 01 40 00 – Quality Assurance and Quality Control

D. Section 01 65 00 – Commissioning of Systems

E. Division 26 - Electrical

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements and are suitable for the use intended. Pumps and motors specified for variable speed operation through a variable frequency controller shall be capable of operating at low reduced speed for extended periods of time without over heating and can operate without excessive vibrations or harmonies at any speed.

C. Submit pump and motor performance data, pump curves showing operation points, NPSHR, curve, submergence requirements, bhp, and efficiencies. Where variable frequency drives are involved, include VFD analysis.

D. Submit shop drawings showing pump dimensions, weights, materials of construction and assembly.

E. Descriptive literature, bulletins and/or catalogs of the equipment.

F. Provide written copies of manufacturer's warranties on products described in this specification section.

G. A complete total bill of materials of all equipment

H. A list of the manufacturer's recommended spare parts.

I. Complete motor and control systems data.

J. Provide Equipment Operation and Maintenance Manuals to the Owner per Section 01 73 00.

K. Submit pump and motor testing reports, per this section. Submit proposed pump and motor testing procedures and protocol.

L. Submit a copy of this specification section, with addendum updates included, with each paragraph clearly-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. If deviations from the specifications are indicated and, therefore requested by the Contractor, the submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification for any requested deviations to the specification requirements, with the submittal shall be cause for rejection of the entire submittal with no further consideration. The Owner retains the right to reject any proposed deviations in favor of this specification, as written.

1.4 QUALITY ASSURANCE

A. Manufacturer: Company specializing in the manufacturing of the pumps and motors specified in this section, with a minimum of five (5) years documented experience.

B. Install and operate pumps and motors in accordance with the manufacturer's recommendations.

1.5 MAINTENANCE SERVICE

A. Furnish service and maintenance of the pumps and motors for one (1) year from date of substantial completion.

1.6 WARRANTY

A. Rotary Lobe Pumps supplied under this section shall be warranted to be free from defects in workmanship, design and materials for a period of two (2) years from the date of Substantial Completion. If any part of the equipment should prove to be defective during the warranty period, the MANUFACTURER at no expense to the OWNER shall replace the part.

B. Include coverage of all pumps, motors, bearings, seals, wear plates, and valves for a period of one year from the date of substantial completion.

PART 2 PRODUCTS

2.1 ROTARY LOBE PUMPS FOR DEWATERING FEED

A. Manufacturers: Provide rotary lobe dewatering feed pumps and motors meeting the requirements of this specification from one of the following manufacturers. Manufacturers meeting the requirements of this specification but not listed here may be considered in accordance with the Contract Documents and the Instructions to Bidders.

1. Boerger rotary lobe pumps, Minneapolis, Minnesota
2. Vogelsang rotary lobe pumps, Ravenna, Ohio.
3. Or approved equal.

B. General

1. The equipment covered by these Specifications shall be of standard units of proven ability as manufactured by reputable concerns having long experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed as shown on the Drawings.
2. All equipment shall be designed and built for 24-hour continuous service at any and all VFD speeds between 6 and 60 Hz, without overheating, without cavitation, and without excessive vibration or strain.
3. The pumping units required under this section shall be complete. All parts shall be so designed and proportioned as to have liberal strength, stability, and stiffness and to be especially adapted for the service to be performed. Ample room for inspection, repairs and adjustment shall be provided.
4. Stainless steel nameplates giving the name of the MANUFACTURER, the pump serial number and material code and all other pertinent data shall be attached to each pump, motor, and control panel.
5. All working parts of the pumps and motors, such as bearings, wearing rings, shaft, sleeves, etc., shall be standard dimensions built to limit gauges or formed to templates, such that parts will be interchangeable between like units and such that the OWNER may, at any time in the future, obtain replacement and repair parts for those furnished in the original machines.
6. The nameplate ratings of the motors shall not be exceeded, nor shall the design service factor be reduced when the pump is operating at any point on its characteristic curve at maximum speed.
7. Mechanical equipment, including drives and electric motors shall be supplied and installed in accordance with applicable OSHA regulations. The noise level of motors, unless otherwise noted, shall not exceed 85 dBA measured 3 meters from the unit under free field conditions while operating on utility power.
8. All lubrication fitting shall be brought to the outside of all equipment so that they are readily accessible from the outside without the necessity of removing covers, plates, housings, or guards.

C. Pumps

1. General:

a. The Rotary Lobe Pumps shall be designed to be abrasion resistant for applications in wastewater treatment plants.

b. The ratio of the axial length of the lobe as compared to the lobe diameter (length/diameter) shall not exceed 1.0.

System and Fluid Conditions	
Fluid name	Waste Activated Sludge (WAS)
DS Content (%)	0.7 to 1.2%
Temperature (°C)	10 to 25º
pH Value	6.0 to 9.5
Specific Gravity	1.00 to 1.05
Design Capacity at 300 RPM (gpm)	30 - 125
Normal Operating Flow (gpm)	65
Speed at Normal Flow (rpm)	< 200
Suction Condition (ft)	8.0 maximum
Discharge Head (ft)	20 – 70
Duty (hrs/day)	7
Pump Unit Requirements	
Drive Type	geared motor
Drive Arrangement	piggyback or in-line
Motor Power (HP)	7.5 hp maximum, inverter duty
Suction Flange	4" ANSI 150 lbs
Discharge Flange	4" ANSI 150 lbs

c. The pumps shall be of the positive displacement, rotary lobe type, designed to pump secondary wastewater sludge.

d. All fluid-wetted parts including the mechanical seal shall be replaceable through the quick release front cover without disassembly of coupling, drive unit or the pipe system.

e. The pumps shall be designed to temporarily run dry and to operate in either direction. Oil-quench for protection of the mechanical seal is mandatory. Seal water flush systems are not acceptable.

f. The pumps shall be constructed with an oil-filled intermediate chamber between the pump casing and the gearbox with the following functions:

i. Oil-Quench (Lubrication and cooling) of the mechanical seals

ii. Detection of seal failures

iii. Buffer zone to the sealed timing gear

g. Oil drain of gearbox and intermediate chamber shall be easily accessible with side mounted drain screw.

h. The rotor/shaft connection shall be oil-lubricated fed by an intermediate chamber and shall not come in contact with the pumped fluid.

2. Pump Construction:

a. The pump casing shall be manufactured in a single block construction (Cast iron ASTM A48 grade 40, Brinell hardness 264 Brinell). Multiple Piece Design Pump Casings held together by screw connections are not acceptable.

b. The rear of the pump casing and the front cover shall be protected with replaceable wear plates with a hardness of 550 Brinell. The front cover protection plate shall be reversible. The pump casing shall be equipped with radial pump casing protection plates. Pump casings without radial liners are not acceptable.

c. The quick release cover shall be held in place by four eye nuts. The stationary threaded studs shall keep the front cover on the same level as the pump casing in the process of opening the pump for easy handling.

d. Rotors shall be dual lobe design with abrasion-resistant Buna-N. The contour of the rotor shall be that the outside radius of the rotor and the inner radius of the radial liner are identical over a minimum 2-inch sealing line. Stacking of lobes is not acceptable. Rotors shall be keyed to the shaft with one central screw to a cylindrical thread inside the shaft. The cast iron core of the rotor shall be equipped with a female thread to enable the removal of the rotor from the shaft with ease. Rotor/shaft designs with a cover disc and/or spring washers are not acceptable.

e. The shafts shall be non-sludge-wetted, the rotor / shaft connection shall be lubricated with quench fluid of the intermediate chamber. They shall be timed in their rotation by straight cut timing gears running in a separate oil chamber, which also contains the ball and roller bearings for each shaft. Sludge wetted rotor / shaft connections are not acceptable. The shafts shall be constructed from carbon steel AISI 4140.

f. The pumps shall be fitted with maintenance free, quenched mechanical seals with duronit seal faces. The seals shall be operating in a common oil-filled intermediate chamber (Quench for lubrication and cooling). Purge systems for the seals are not acceptable. The rotating holding bush shall be locked in a fixed radial position by a keyway that also holds the rotor in place. Seal designs that open during rotor replacement are not acceptable. No sleeves shall be necessary for the mechanical seal set up. Design of the pump shall allow removal and replacement of the seal via the front cover.

g. Bearings and timing gear shall be located in a common oil-filled cast iron gearbox, fitted with a built in sight class to monitor oil level. The timing gear shall maintain non-contact between the rotors. Bearing life to be designed for L-10 bearing life rating of 100,000 hours at design conditions.

h. Suction and discharge connections from galvanized steel shall be sized as noted.

i. Pump and drive fitted on common base, made from galvanized steel.

j. Vibration: Pumps and motors shall operate at any point within their operating range without undue noise and vibration. Vibration at any point in the operating range shall not exceed the limits allowed by the Hydraulic Institute.

D. Motors

1. General: Each unit shall consist of a pump/geared motor configuration and shall be supplied with an in-line reducer complete with electric motor, horsepower as noted, 1800 RPM, 3 phase, 60 Hz, 230 Volt, TEFC, 1.15 SF, Class F Insulation. Provide external 120V AC motor cooling fan.

2. All motors shall be built in accordance with latest NEMA, IEEE, ANSI and AFBMA standards where applicable.

3. Motors shall be premium efficiency.

E. Spare parts to be furnished

1. One (1) set of mechanical seals and o-rings for each pump model

2. One (1) set of lobes and o-rings for each pump model

3. One (1) set of axial protection plates for each pump model

4. One (1) set of radial liners

5. One (1) set of special tools for each pump model (if required)

PART 3 EXECUTION

3.1. EXAMINATION

A. Verify all pumps, motors, valves, and materials are present and meet the requirements of these Specifications.

3.2. INSTALLATION PERSONNEL

A. The Contractor shall employ qualified competent personnel for the installation, testing, and start-up of all pumps. Contractor shall include as part of the contract, the services of a factory representative from the firm supplying the pumping equipment to supervise the installation and start-up of all pumps. After installation and before start-up, all pumps shall be realigned within the manufacturer's specifications by the representative. The field representative shall remain on the job until each pump is operating satisfactorily at no additional cost to the Owner.

3.3. LUBRICANTS

A. The Contractor shall furnish all necessary oils, lubricants, grease guns, or other necessary applicators and shall lubricate the mechanical equipment prior to initial operation. The grade of oil and grease furnished by the Contractor shall be in accordance with the recommendation of the equipment manufacturer. The Contractor shall supply a 12-month supply of each lubricant.

3.4. COORDINATION OF RELATED EQUIPMENT

A. Contractor shall carefully coordinate pump, pump motor, variable frequency drive, and controller manufacturers so that the completed system operates satisfactorily under all operating conditions.

B. Controls for the dewatering feed pumps shall be located in the main control panel for the screw press dewatering system. Contractor shall provide wiring between the screw press control panel and the dewatering feed pumps.

3.5. INSTALLATION

A. Install pumps and motors in accordance with shop drawings and manufacturer's recommendations.

B. Interface with suction and discharge piping to provide a complete waterproof seal.

C. Set pumps to provide a constant centerline alignment through all discharge and suction piping.

D. Install electrical and pump controls in accordance with the manufacturer's recommendations and the electrical division of these Technical Specifications. Controls for the dewatering feed pumps shall be located in the main control panel for the screw press dewatering system.

3.6. STARTUP SERVICES

A. Provide a factory-trained representative to demonstrate operation and maintenance of the pump and motors.
   1. (1) day for startup and commissioning
   2. (1) day for training

B. Provide Equipment Operation and Maintenance Manuals per Section 01 73 00.

C. The pump manufacturer shall analyze the complete pump and piping system and recommend such supports and modifications as necessary to eliminate harmonics and vibration in the system when operated over the operational speed range. Pump bases and foundations, as well as piping and supports as shown on the plans shall be modified and enlarged as necessary to provide adequate support and vibration control.

D. The installed pumping units shall operate without excessive vibration. Balance of rotating parts shall be maintained throughout the pumps rated performance curve, which will include shut-off points. Vibration amplitude shall not exceed Hydraulic Institute limits, at any operating point along pump curve. If requested by Engineer, Contractor shall provide for an independent vibration analysis at no cost to the Owner to verify vibration requirements are met. Contractor shall be responsible to make required adjustments to ensure vibration is less than the maximum allowable amount. Excessive vibration will be defined as that which exceeds the limits outlined by the Hydraulic Institute for this type of pump.

E. Perform hydraulic testing for each pump verifying performance on the pump curve. Data shall include flow measurement and discharge pressure at 3 different operation points for each pump. Data shall also include voltage, amperage, and motor speed for each pump taken at each of the recorded operating points.

END OF SECTION

SECTION 43 24 13
VERTICAL TURBINE PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. The Contractor shall provide all labor, equipment, and materials to furnish and install the vertical turbine pumps and controls as indicated in the Drawings and Specifications. All pumps provided under this specification shall be from the same manufacturer.

B. Santaquin Water Reclamation Facility Tags for the vertical turbine pumps and motors at the reclaim water pump station that are upgraded during this phase:
   1. New Pump: Equipment Tag Reference: 75-P-101-4
   2. Refurbished Pump with New Impeller: Equipment Tag Reference: 75-P-101-1

1.2 RELATED SECTIONS

A. Division 1 – General Requirements

B. Section 01 20 00 – Measurement and Payment

C. Section 01 33 00 – Submittals Procedures

D. Section 01 40 00 – Quality Assurance and Quality Control

E. Section 01 65 00 – Commissioning of Systems

F. Section 01 73 00 – Installation, Operation, and Maintenance Manuals

G. Section 09 90 00 – High Performance Coatings

H. Section 26 29 23 – Variable-Frequency Drives

I. Section 40 05 10 – Pipe and Fittings

J. Section 43 30 00 – Hydraulic Process Valves

K. Division 26 – Electrical

1.3 REFERENCES

A. AWWA Standard E101 – Vertical Turbine Pumps – Line Shaft and Submersible Types

B. NEMA MG-1 Motor and Generators

C. ANSI/HI 9.8 Pump Intake Design

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Vendor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner shall be the final authority for determining the acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements and are suitable for the intended use.

D. Submit pump and motor performance and nameplate data. Data for each unit shall include:

Submergence requirements

1. Brake horsepower
2. Pump and motor efficiencies
3. Gravitational weight of rotating pump parts
4. Hydraulic down thrust during normal operation and at shut-off head
5. Size and dimensions of suction intake
6. Line shaft sizing calculations

E. Submit pump and motor manufacturer and model number, number of pump stages, pump and motor size and dimensioning data, and motor protection and efficiency.

F. Shop tests

A. All pumps shall be shop performance tested.

B. All tests shall be witnessed by a Registered Professional Engineer who may or may not be an employee of the manufacturer. The witness shall sign and seal all copies of the pump curves certifying that the pump will perform in accordance with the submitted curve data and the requirements of this specification.

C. The tests shall be in accordance with Section A6 of AWWA E101 and the standards of the Hydraulic Institute. For variable speed pumps curves shall show at four speeds including full speed operation and three reduced speeds between 30 and 60 Hertz. Readings shall be taken at 6 evenly spaced points including shutoff, design point, and 125 percent of the best efficiency point.

D. Curves shall be run in the shop utilizing either the job motor or a calibrated shop motor. Report at a minimum pump curves, horsepower, wire to water efficiency, and NPSHr.

E. Certified curves shall be submitted. The curve from the performance test shall be approved by the Engineer prior to shipment.

G. Submit pump curve showing performance requirements are satisfied. Curves shall include head, flow, impeller trim, efficiency, net positive suction head required, and horsepower.

H. Submit shop drawings showing pump dimensions (column, bowl, shaft, discharge head, suction vessel, and etc.).

1.5 QUALITY ASSURANCE

A. Manufacturer: Company specializing in the manufacturing of the pumps and motors specified in this section, with a minimum of five (5) years documented experience.

B. Install and operate pumps and motors in accordance with the manufacturer's recommendations.

C. Manufacturer will provide a factory trained representative to inspect and certify the installation and oversee the startup of the pumping equipment.

1.6 WARRANTY

A. Warranty: Include coverage of all pump and motor system including but not limited to pump, motor, impellers, bearings, seals, wear plates, wear rings, and pump and motor shafts for a period of one (1) year from the date of substantial completion, or 18 months from installation, whichever is greater. Warranty shall cover any problems created from vibration, manufacturing defects, improper installation, or other defective work.

B. Major components that fail to perform or prove defective in service during the warranty period because of defect in workmanship or materials shall be replaced, repaired, or satisfactorily modified to the satisfaction of the Owner. The warranty shall include removal, reinstallation, freight, start-up, testing and calibration, as necessary.

1.7 PERFORMANCE REQUIREMENTS

A. Submit under provisions of Section 01 33 00.

B. Vertical Turbine Pumps for wet well at the Santaquin Water Reclamation Facility.

1. Design Duty Point

1.	Design capacity:	1250 gpm
2.	Total design head:	160 feet
3.	Minimum corrected bowl efficiency:	80 %

4.	Minimum shut-off head:	245 feet
5.	Maximum pump speed:	1770 rpm
6.	Maximum NPSHr at design point:	17 feet
7.	Horsepower:	75 hp
8.	Approximate setting depth: (Contractor to field verify)	10 feet

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURER

A. Manufacturers: Provide new and refurbished vertical turbine pumps and motors meeting the requirements of this specification from one of the following:
   1. Flowserve
   2. Or approved equal. Manufacturers meeting the requirements of this specification but not listed here may be considered in accordance with the Contract Documents and the Instructions to Bidders.

2.2 DESIGN

A. Refurbished Pump:
   1. Refurbish Pump 1 (70-P-201-1) with new impeller and coatings per Specification 09 90 00.
      a. Impellers: The impellers shall be silicon bronze ASTM B584 and shall be the enclosed type. The impellers shall be statically, dynamically, and hydraulically balanced and shall be factory trimmed to match the performance conditions indicated.
      b. Motor: The contractor shall remove the existing motor and install a new motor per section 2.2 C.

B. New Pump:
   1. Vertical water lubricated turbine pump with bowl assembly, column, line shaft, top shaft, suction screen, discharge head, and driver as specified. Unless otherwise stated herein, the pump shall in all respects conform to AWWA E101 Vertical Turbine Pumps - Line Shaft and Submersible Types and shall comply with all local and state safety regulations.
      a. Discharge head: The discharge head shall be of close grain, cast iron, ASTM A48 Class 30, free of sand holes and other defects, accurately machined and with a surface discharge. The discharge shall be machined and drilled to ANSI B16.1 class 125 standards and shall have a nominal diameter of 8”. The discharge head shall be provided with a shaft packing box and a renewable bronze bushing.
      b. Stuffing box: The cast iron stuffing box shall be of ASTM A48 Class 30 rated for the discharge pressures anticipated and shall be fitted with graphite-impregnated acrylic packing and have either a lantern ring or grease chamber below the first packing ring. The packing gland shall be

of bronze ASTM B584 alloy C932 or 316 stainless steel with stainless steel bolting and adjusting nuts. A rubber water slinger shall be secured to the shaft above the packing gland. Provide discharge tubing to evacuate seal water to the floor drain, or returned to wet well through the discharge head.

c. Top line shaft: The top line shaft (head shaft) shall be of ASTM A582 Type 416 stainless steel and have a surface finish no to exceed RMS 40 (ANSI B46.1) and shall not exceed 10 feet in length. The diameter of the shaft and coupling shall be designed in accordance with AWWA E101. To ensure accurate alignment of the shafts, they shall be straight within 0.005 in. total indicator reading for a 10 ft section; the butting faces shall be machined square to the axis of the shaft. The top shaft adjusting nut shall be bronze of ASTM B584 and shall be positively locked in position with a steel lock screw or washer of ASTM A108 Grade 1018.

d. Column line shaft: The column lineshaft shall be of 416 stainless steel and polished to a surface finish not to exceed RMS 40 (ANSI B46.1). The lineshaft sections shall be furnished in interchangeable sections not over ten feet in length. The butting faces shall be machined square to the axis of the shaft, with maximum permissible axial misalignment of the thread axis with the shaft axis of 0.002" in 6". The diameter of the shaft shall be no less than that determined by AWWA E101 Section A5.5, and shall be such that elongation due to hydraulic thrust will not exceed the axial clearance of the impellers in the pump bowls. The shafts shall be straight within 0.005 in. total indicator reading for a 10 ft. section. The lineshaft shall be provided with A276 Type 304 stainless steel sleeves at the location of each line shaft bearing. The line shaft bearing shall be of 70 minimum shore hardness, neoprene, snap-in type, internally spiral-grooved to flush out sand and other abrasives and mounted in bronze B584 alloy 836 bearing retainers held in position in the column coupling by means of the butted ends of the column pipe. Bearing spacing shall not exceed 10'.

e. Discharge column pipe: The discharge column pipe shall be threaded and of ASTM A53 grade B steel pipe in interchangeable sections not over 10' in length, 8" in diameter, and shall conform to the specifications in Table 2 of AWWA E101 Section A4.3. The pipe size shall be such that the friction loss will not exceed 5' per 100', based on the rated capacity of the pump.

f. Bowl assembly: The pump bowls shall be of close grain, cast iron ASTM A48 Class 30. The water passages shall be lined with porcelain enamel, shall be free of blow hoes, sand holes, and other detrimental defects, and shall be accurately machined and fitted. The pump bowls shall be equipped with replaceable seal rings, of either bronze or stainless steel, on the suction side of the enclosed impellers.

g. Impellers: The impellers shall be silicon bronze ASTM B584 and shall be the enclosed type. The impellers shall be statically, dynamically, and hydraulically balanced and shall be factory trimmed to match the performance conditions indicated.

h. Bowl assembly shaft: The bowl shaft shall be of A582 Type 416 stainless steel, turned, ground and polished to a surface finish not exceed RMS 40 (ANSI B46.1). The shaft shall be supported by bronze bearings of ASTM B584 above and below each impeller. The suction case bearing shall be grease lubricated and protected by a bronze sand collar of ASTM B584. The size of the shaft shall be no less than that determined by AWWA E101 Section A4.3.

i. Suction strainer: A basket type suction strainer shall be provided of ASTM A108 galvanized steel or stainless steel and shall have a net inlet area equal to at least three times the impeller inlet area. The maximum unit opening shall not be more than 75 percent of the minimum opening of the water passage through the bowl or impeller.

j. Motor: Install new motor per section 2.2 C.

C. New Motors:

1. Weather-protected type 1 (WP-1), vertical hollow shaft, manufactured by U.S. Motors or General Electric, with all materials, workmanship, and tests conforming with the applicable specifications of the National Electric Manufacturer's Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE), the American Standards Association (ASA), the Anti-Friction Bearing Manufacturing Association (AFBMA), and the following requirements:

   a. NEMA MG-1

      i. Premium Efficiency
      ii. Design B
      iii. Code F or G

   b. Horsepower: 75 hp derated for altitude. Check altitude to see if derating is necessary.
   c. Time rating: Continuous
   d. Maximum ambient temperature: 40°C
   e. Temperature rise: Class B
   f. Insulation system designation: Class F
   g. Synchronous speed: 1770 rpm
   h. Frequency: 60 hz
   i. Phases: 3
   j. Voltage: 460
   k. Service Factor: 1.15
   l. Backspin protection: non-reverse ratchet (ball bearing type)
   m. Motor bearings: The motor bearings shall be antifriction and designed to carry the weight of all rotating parts plus the maximum hydraulic thrust load under all conditions of operation. The L-10 life at the operating point shall be 44,000 hours.
   n. Shaft: The motor shaft shall be the vertical hollow shaft type of ASTM A582 Type 416 stainless steel. The shaft shall be accurately machined and polished and of sufficient size to transmit full driver output without excessive flexure or stressing. Shaft deflection shall not exceed 0.002 inches measured at the end of the shaft when operating at the specified

design condition.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify all pumps, motors, and materials are present and meet the requirements of the Specifications.

B. Verify site is ready to receive pump systems. Coordinate with related items of work.

C. Verify all close-coupled vertical turbine pumps shall be factory assembled. The motors and motor shafts of the two-piece top shaft shall be shipped un-mounted for field installation by the Contractor.

3.2 INSTALLATION PERSONNEL

A. The Contractor shall employ qualified competent personnel for the installation, testing, and start-up of all pumps and controls. Contractor shall include as part of the contract, the services of a field representative from the firm supplying the pump system to supervise the installation and start-up of the system. The field representative shall remain on the job until each pump is operating satisfactorily and the control system has been fully tested for conformance to the Contract Documents.

3.3 INSTALLATION

A. Install pumps, motors, and materials in accordance with shop drawings and manufacturer's recommendations.

B. Interface with discharge piping to provide a complete waterproof seal. Ensure no stresses are imparted on the mounting flanges from poor alignments.

C. Set pumps to provide a constant centerline alignment through all discharge piping.

D. Provide trained and qualified personnel to adjust the impellers to the proper bowl running clearance as identified by the manufacturer.

E. Place pump bowls and discharge column vertical in wet wells, or non-pressurized vessel, as shown on the Drawings at appropriate settings with required clearance.

F. Install electrical and pump controls in accordance with the manufacturer's recommendations and Division 26 - Electrical, of these Technical Specifications.

G. Test installation per section 01 65 00 - Commissioning of Systems.

3.4 STARTUP SERVICES

A. Provide a factory-trained representative for 8 hours to demonstrate operation and maintenance of the pump and motor and to make necessary adjustments to pump setting, control valves, etc. to provide proper system operation.

B. Provide three (3) copies of Equipment Operation and Maintenance Manuals to the Engineer.

C. The pump and motor shall be installed in strict compliance with the pump Manufacturer's instructions. The correct motor rotation shall be confirmed prior to installing the top shaft and the impellar lateral adjustment shall be in accordance with the pump Manufacturer's instructions.

D. The installed pumping units shall operate without excessive vibration. Balance of rotating parts shall be maintained throughout the pumps rated performance curve, which will include shut-off points. Vibration amplitude shall not exceed Hydraulic Institute limits, at any operating point along pump curve. If requested by Engineer, Contractor shall provide for an independent vibration analysis at no cost to the Owner to verify vibration requirements are met. Contractor shall be responsible to make required adjustments to ensure vibration is less than the maximum allowable amount. Excessive vibration will be defined as that which exceeds the limits outlined by the Hydraulic Institute.

E. The factory-trained representative shall perform on-site hydraulic testing for each pump to verify performance on the pump curve. Data shall include flow measurement and discharge pressure at three (3) different points for each pump.

END OF SECTION

SECTION 43 25 05
SUBMERSIBLE WASTEWATER PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnish and install one new submersible pump and motor equipped with a flush valve

B. Removal two existing submersible pump and motors and re-install existing pumps with new guiderails and discharge connections.

C. Equipment Tag No.:

- 05-P-101-3

1.2 RELATED SECTIONS

A. Section 01 22 00 – Measurement and Payment

B. Section 01 33 00 – Submittal Procedures

C. Section 01 40 00 – Quality Requirements

D. Section 01 65 00 – Commissioning of Systems

E. Section 01 78 23 – Operation and Maintenance Data

F. Section 03 30 00 – Cast-in-place Concrete

G. Section 09 90 00 – Protective Coatings

H. Division 26 – Electrical

I. Division 43 – Material Handling Equipment

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements, and are suitable for the use intended.

C. Submit a copy of this specification section, with addendum updates included, with each paragraph clearly marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. If deviations from the

specifications are indicated and, therefore requested by the Contractor, the submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification for any requested deviations to the specification requirements, with the submittal shall be cause for rejection of the entire submittal with no further consideration. The Owner retains the right to reject any proposed deviations in favor of this specification, as written.

D. Submit pump and motor performance data, pump curve data (system head-flow curve, operating point, horsepower, efficiency, NPSHr), pump and motor models, and impeller type and size.

E. Submit shop drawings showing pump dimensions, pump and motor weight, detailed drawings for installation requirements, materials of construction, connections and sizes, submergence requirements, rail system and connections, supports and braces, discharge elbow, and access hatch requirements.

F. Submit factory certified pump curve showing performance requirements are satisfied prior to shipment. Indicate specified operation points and recommended limits of operation. Submit pump and motor testing reports.

G. Provide written copies of manufacturer's warranties on products described in this specification section.

H. Submit Operation and Maintenance (O&M) Manuals in accordance with Section 01 78 23.

1.4 QUALITY ASSURANCE

A. Install and operate pumps and motors in accordance with the manufacturer's recommendations.

B. Unit responsibility: To ensure coordination, all pumps, motors, power cable, base elbows, control panel, and accessories shall be supplied by one pump manufacturer.

1.5 WARRANTY

A. Warranty: Include coverage of all pumps, motors, bearings, seals, wear plates, and accessories for a minimum of one (1) year from the date of startup and prorated for a period of five (5) years from the date of startup.

B. Warrant all equipment provided under this section, regardless of whether it is manufactured by the pump manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to

support the product and employed by the pump supplier shall service the pumps and motors.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Box, crate, or otherwise completely enclose and protect all equipment during shipment, handling, and storage in accordance with the manufacturer's recommendations.

B. Protect equipment from exposure to elements and keep all items dry.

C. Store motors, electrical equipment, and other equipment with moving parts in weather tight enclosures.

D. Painted Surfaces: Protect against impact, abrasion, discoloration, and other damage.

E. Protect electrical equipment, controls, and insulation against moisture or water damage.

PART 2 PRODUCTS

2.1 GENERAL

A. The pumping units shall all be supplied by one manufacturer and shall be complete including submersible pump and motor, discharge elbow, mix flush valve, guide rail system brackets and supports, mechanical seals, and related and required accessories.

B. Each major piece of equipment shall be furnished with a stainless-steel nameplate (with embossed data) securely mounted to the body of the equipment. As a minimum, the nameplate for the pumps shall include the manufacturer's name and model number, serial number, rated flow capacity, head and speed. As a minimum, nameplates for motors shall include the manufacturer's name and model number, serial number, horsepower, speed, input voltage, amps, number of cycles, power and service factors.

C. Pumping units shall be designed for the performance and design requirements as shown in the Contract Documents.

2.2 PERFORMANCE REQUIREMENTS

A. Furnish and install one submersible non-clog wastewater pump(s). The pump shall be equipped with a submersible explosion-proof electric motor, connected for operation on 460-volts, 3~ phase, 60-hertz 3-wire service, with 50 feet of submersible cable (SUBCAB) suitable for submersible pump applications. The power cable shall be sized according to National Electrical Code (NEC) and Insulated Cable Engineers Association (ICEA) standards and also meet with P-MSHA Approval.

B. Pump and Motor Design:

1. Continuous operating service at any and all points within the specified range of operation, without overheating, without damaging cavitations, and without excessive vibration or noise at site conditions, elevations, and expected ambient temperatures.
2. Suitable for pumping raw unscreened sewage
3. Discharge elbow permanently installed in wet well along with discharge piping.
4. Pump will automatically connect to discharge elbow when lowered in place.
5. Be easily removed for inspection and service requiring removal of no bolts, nuts, or other fastenings and do not require personnel to enter the wet well.
6. Rated for explosion proof, Class 1, Division 1, Group C and D hazardous locations.
7. Non-overloading throughout the entire range of operation without employing a service factor.

C. Design Operating Conditions: 05-P-101-3

1.	Minimum hydraulic efficiency, %	69
2.	Nominal pump speed, rpm	1800
3.	Shut-off head, feet	116
4.	Motor horsepower, hp	30
5.	Power supply	460V, 3 phase, 60 Hz
6.	Discharge diameter, inches	6
7.	Site elevation, feet	4,810

D. Design Operating Point for One Duty Pump Condition:

1.	Flow Capacity, gpm	1,700
2.	Total dynamic head, feet	52.8

E. Design Operating Point for Two Duty Pump Condition:

1.	Flow Capacity, gpm	1,375
2.	Total dynamic head, feet	63.7

2.3 MANUFACTURER

A. The following manufacturers meet the performance requirements of this specification and are also subject to the requirements of these specifications. Manufacturers meeting the requirements of this specification but not listed below may be considered with proper documentation.

1. Xylem Water Solutions Flygt Products NP Model 3171, flush valve 4901.

2.4 PUMP CONSTRUCTION

A. Major pump components shall be of grey cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. The lifting handle shall be of stainless steel. All exposed nuts or bolts shall be of stainless-steel construction.

B. All metal surfaces coming into contact with the pumpage, other than stainless steel or brass, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.

C. Sealing design shall incorporate metal-to-metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile rubber O-rings. Fittings will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit.

D. Rectangular cross sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondary sealing compounds, elliptical O-rings, grease or other devices shall be used.

2.5 MOTOR

A. The pump motor shall be a National Electrical Manufacturers Association (NEMA) B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber.

B. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356°F). The stator shall be insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95 percent.

C. The motor shall be inverter duty rated in accordance with NEMA MG1, Part 31.

D. The stator shall be heat-shrink fitted into the cast iron stator housing. The use of multiple step dip and bake-type stator insulation process is not acceptable. The use of pins, bolts, screws or other fastening devices used to locate or hold the stator and that penetrate the stator housing are not acceptable.

E. The motor shall be designed for continuous duty while handling pumped media of up to 104°F. The motor shall be capable of no less than 30 evenly spaced starts per hour.

F. The rotor bars and short circuit rings shall be made of aluminum. Three thermal switches shall be embedded in the stator end coils, one per phase winding, to monitor the stator temperature. These thermal switches shall be used in conjunction with and

supplemental to external motor overload protection and shall be connected to the motor control panel.

G. The junction chamber shall be sealed off from the stator housing and shall contain a terminal board for connection of power and pilot sensor cables using threaded compression type terminals. The use of wire nuts or crimp-type connectors is not acceptable. The motor and the pump shall be produced by the same manufacturer.

H. The motor service factor (combined effect of voltage, frequency and specific gravity) shall be 1.15. The motor shall have a voltage tolerance of +/- 10 percent. The motor shall be designed for continuous operation in up to a 40°C ambient and shall have a NEMA Class B maximum operating temperature rise of 80°C. A motor performance chart shall be provided upon request exhibiting curves for motor torque, current, power factor, input/output kW and efficiency. The chart shall also include data on motor starting and no-load characteristics.

I. Motor horsepower shall be sufficient so that the pump is non-overloading throughout its entire performance curve, from shut-off to run-out. The motor and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet or greater.

J. The motor shall be FM approved for use in NEC Class I, Division I, Groups C and D hazardous locations.

K. Motor shall be labeled and listed by a recognized electrical testing laboratory for the design application.

2.6 PROTECTION

A. Each pump motor stator shall incorporate three thermal switches, one per stator phase winding and be connected in series, to monitor the temperature of the motor. Should the thermal switches open, the motor shall stop and activate an alarm.

B. A float switch shall be installed in the seal leakage chamber and will activate if leakage into the chamber reaches 50 percent chamber capacity, signaling the need to schedule an inspection.

2.7 CABLE ENTRY SEAL

A. The cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of dual cylindrical elastomer grommets, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter. The grommets shall be compressed by the cable entry unit, thus providing a strain relief function. The assembly shall provide ease of changing the cable when necessary using the same entry seal. The

cable entry junction chamber and motor shall be sealed from each other, which shall isolate the stator housing from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered equal.

2.8 POWER CORD

A. The power cable shall be sized according to the NEC, FM, and CSA standards and shall be of sufficient length to reach from the installed pump location in the wet well to the termination point of the cable at the pump panel or motor controller without the need of any splices. The outer jacket of the cable shall be oil and water resistant and shall be capable of continuous submergence underwater to a depth of 65 feet.

2.9 BEARINGS

A. The integral pump/motor shaft shall rotate on two bearings. The motor bearings shall be sealed and permanently grease lubricated with high temperature grease. The upper motor bearing shall be a two-row angular contact ball bearing. The lower bearing shall be a two-row angular contact ball bearing to handle the thrust and radial forces. The minimum L10 bearing life shall be 50,000 hours at any usable portion of the pump curve.

2.10 MECHANICAL SEALS

A. Each pump shall be provided with a positively driven dual, tandem mechanical shaft seal system consisting of two seal sets, each having an independent spring.

B. The lower primary seal, located between the pump and seal chamber, shall contain one stationary and one positively driven rotating corrosion and abrasion resistant tungsten-carbide ring.

C. The upper secondary seal, located between the seal chamber and the seal inspection chamber shall be a leakage-free seal. The upper seal shall contain one stationary and one positively driven rotating corrosion and abrasion resistant tungsten-carbide seal ring. The rotating seal ring shall have small back-swept grooves laser inscribed upon its face to act as a pump as it rotates, returning any fluid that should enter the dry motor chamber back into the lubricant chamber.

D. All seal rings shall be individual solid sintered rings. Each seal interface shall be held in place by its own spring system. The seals shall not depend upon direction of rotation for sealing. Mounting of the lower seal on the impeller hub is not acceptable. Shaft seals without positively driven rotating members or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces are not acceptable. The seal springs shall be isolated from the pumped media to prevent materials from packing around them, limiting their performance.

E. Each pump shall be provided with a lubricant chamber for the shaft sealing system. The lubricant chamber shall be designed to prevent overfilling and shall provide capacity for lubricant expansion. The seal lubricant chamber shall have one drain and one inspection plug that are accessible from the exterior of the motor unit. The seal system shall not rely upon the pumped media for lubrication.

F. The area about the exterior of the lower mechanical seal in the cast iron housing shall have cast in an integral concentric spiral groove. This groove shall protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.

G. A separate seal leakage chamber shall be provided so that any leakage that may occur past the upper, secondary mechanical seal will be captured prior to entry into the motor stator housing. Such seal leakage shall not contaminate the motor lower bearing. The leakage chamber shall be equipped with a float type switch that will signal if the chamber should reach 50 percent capacity.

H. Seal lubricant shall be non-hazardous.

2.11 PUMP SHAFT

A. The pump and motor shaft shall be a single piece unit. The pump shaft is an extension of the motor shaft. Shafts using mechanical couplings shall not be acceptable. The shaft shall be stainless steel – ASTM A479 S43100-T. Shaft sleeves will not be acceptable.

2.12 IMPELLER

A. The impeller shall be of Hard-IronTM (ASTM A-532 (Alloy III A) 25 percent chrome cast iron), dynamically balanced, semi-open, multi-vane, back swept, screw-shaped, non-clog design. The impeller leading edges shall be mechanically self-cleaned automatically upon each rotation as they pass across a spiral groove located on the volute suction. The leading edges of the impeller shall be hardened to Rc 60 and shall be capable of handling solids, fibrous materials, heavy sludge and other matter normally found in wastewater. The screw shape of the impeller inlet shall provide an inducing effect for the handling of up to five percent sludge and rag-laden wastewater.

B. The impeller to volute clearance shall be readily adjustable by the means of a single trim screw. The impeller shall be locked to the shaft, held by an impeller bolt and shall be coated with alkyd resin primer.

2.13 VOLUTE

A. The pump volute shall be a single piece grey cast iron, ASTM A-48, Class 35B, non-concentric design with smooth passages of sufficient size to pass any solids that may enter the impeller. Minimum inlet and discharge size shall be as specified.

B. The volute shall have a replaceable suction cover insert ring in which are cast spiral-shaped, sharp-edged groove(s). The spiral groove(s) shall provide trash release pathways and sharp edge(s) across which each impeller vane leading edge shall cross during rotation so to remain unobstructed. The insert ring shall be cast of Hard-IronTM (ASTM A-532 (Alloy III A) 25 percent chrome cast iron) and provide effective sealing between the multi-vane semi-open impeller and the volute housing.

2.14 LIFTING/GUIDE RAIL SYSTEM

A. The pump shall be supplied with a mating cast iron 6-inch discharge connection. The pump(s) shall be automatically and firmly connected to the discharge connection, guided by no less than two guide bars extending from the top of the station to the discharge connection.

B. An upper guide rail mounting bracket shall be provided. Use intermediate supports (304 stainless steel) on guide bars as needed. Guide bars shall not support any portion of the weight of the pump. Guide pipes, supports, brackets, and system components shall be 304 stainless-steel.

C. There shall be no need for personnel to enter the wet-well.

D. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal to metal watertight contact. Sealing of the discharge interface with a diaphragm, O-ring or profile gasket will not be acceptable.

E. No portion of the pump shall bear directly on the sump floor.

F. Each pump shall be fitted with 40 feet of 304 lifting chain or stainless-steel cable. The working load of the lifting system shall be 50 percent greater than the pump unit weight.

G. Each pump shall be fitted with appropriate lifting tackle, eye bolts, bail hooks and other necessary fittings for a complete and functional installation. The lift bail shall provide a large open loop so that the bail can be hooked from the surface, precluding the need for personnel to enter the wet well. The bail shall be designed so that standard commercially available shackles and fittings can be used to attach lifting chains.

H. Anchor bolts, guide bar brackets and supports and cable and chain hooks to be type 304 stainless steel.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify all pumps, motors, and materials are present and meet the requirements of these Specifications.

3.2 INSTALLATION PERSONNEL

A. The Contractor shall employ qualified competent personnel for the installation, testing, and startup of all pumps. Contractor shall include as part of the contract, the services of a factory representative from the firm supplying the pumping equipment to supervise the installation and start-up of all pumps. After installation and before startup, all pumps shall be realigned within the manufacturer's specifications by the representative. The field representative shall remain on the job until each pump is operating satisfactorily at no additional cost to the Owner.

3.3 LUBRICANTS

A. The Contractor shall furnish all necessary oils, lubricants, grease guns, or other necessary applicators and shall lubricate the mechanical equipment prior to initial operation. The grade of oil and grease furnished by the Contractor shall be in accordance with the recommendation of the equipment manufacturer. The Contractor shall supply a 12-month supply of each lubricant.

3.4 COORDINATION OF RELATED EQUIPMENT

A. Contractor shall carefully coordinate pump, pump motor, variable frequency drive, and controller manufacturers so that the completed system operates satisfactorily under all operating conditions.

3.5 INSTALLATION

A. Install pumps and motors in accordance with shop drawings and manufacturer's recommendations.

B. Interface with discharge piping to provide a complete waterproof seal.

C. Install electrical and pump controls in accordance with the manufacturer's recommendations and the electrical division of these Technical Specifications. Verify controls and programming is complete prior to start-up.

D. Repair any damaged coatings in accordance with the pump manufacturer's recommendations.

3.6 TESTING

A. Each actual pump and motor, including motor cables, to be supplied on the project shall be non-witnessed factory tested for discharge flow, discharge head, horsepower, and efficiency.

B. Perform hydraulic field testing of each pump verifying performance and conformance with the specified design conditions. Data shall include discharge flow, discharge head, voltage, amperage, and motor speed.

3.7 START-UP SERVICES

A. The equipment manufacturer shall furnish the services of a qualified factory trained field service engineer per Section 01 75 16 to inspect the installation and instruct the Owner's personnel on the operation and maintenance of the pumping units. After the pumps have been completely installed and wired, the Contractor shall have the manufacturer do the following:

1. Megger stator and power cables.
2. Check seal lubrication.
3. Check for proper rotation.
4. Check power supply voltage.
5. Measure motor operating load and no-load current.
6. Check level control operation and sequence.

B. During this initial inspection, the manufacturer's service representative shall review recommended operation and maintenance procedures with the owner's personnel.

C. The pump manufacturer shall analyze the complete pump and piping system and recommend such supports and modifications as necessary to eliminate harmonics and vibration in the system when operated over the operational speed range. Pump bases and foundations, as well as piping and shaft supports as shown on the plans shall be modified and enlarged as necessary to provide adequate support and vibration control.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 43 25 06
MIXED LIQUOR RECIRCULATION PUMPS

PART 1 GENERAL

1.1 SUMMARY

A. Equipment Tag References: 16-P-804, 16-P-805

B. Work described in this section includes providing all labor, equipment, materials, tools, and incidentals required for a complete and operable installation of Mixed Liquor Recirculation Pumps as shown on the Plans and specified herein.

1.2 RELATED SECTIONS

A. Section 01 20 00 – Measurement and Payment

B. Section 01 33 00 – Submittal Procedures

C. Section 01 40 00 – Quality Requirements

D. Section 01 60 00 – Product Requirements

E. Section 01 65 00 – Commissioning of Systems

F. Section 01 78 23 – Operation and Maintenance Data

G. Section 26 05 55 – Motors

H. Section 26 90 50 – Process Instrumentation Meters and Transmitters

I. Section 26 92 10 – Control Systems

J. Section 43 05 10 – Equipment General Provisions

K. Division 03 – Concrete

1.3 SUBMITTALS

A. Submittals shall be provided in accordance with Section 01 33 00 Submittal Procedures and 43 05 10 Equipment General Provisions.

B. Design Information Submittal: The Contractor shall submit the following items, at minimum. Engineer reserves the right to request additional submittals as deemed necessary.

1. Manufacturer's Certificate: Certify that product(s) meet or exceed the specified requirements and are suitable for the use intended. Pumps and motors specified for variable speed operation through a variable

frequency controller shall be capable of operating at low reduced speed for extended periods of time without overheating and to operate without excessive vibrations or harmonics at any speed.

2. VFD Analysis: The variable frequency drive (VFD) analysis included with the submittal shall be from full speed (60 hz) to at least 30 hz (in 5 hz increments) or to the manufacturer's recommended minimum speed, whichever is less. The data shall be in tabular and graphical forms.

3. Submit shop drawings showing pump dimensions, pump and motor weight, detailed drawings for installation requirements, materials of construction, connections and sizes, submergence requirements, supports and braces, discharge elbow, size and location of required piping and utility connections, structural supports, construction details, overall weight of the equipment (and major components), and materials of construction of all components. Include Revit models for all equipment items for incorporation into Engineer's model and construction plans.

4. Detailed information for all ancillary items such as hardware, mounting frames, etc.

5. Factory coating system.

6. Station Drawing for Accessories

7. Electrical Motor Data

8. Anchor bolt sizing / calculations prepared by a Professional Engineer licensed in the state of Utah.

9. Technical manuals

10. Process and Instrumentation Diagram of the system, detailing the equipment supplied and showing equipment that shall interface with the system.

11. Product Data: Vendor shall submit the following minimum information as part of their Product Data Submittal for each model or type of unit supplied by the Vendor:

a. Manufacturer's catalog information.

b. Manufacturer's specifications for materials and manufacturing.

c. Installation list of pumps in the United States, including the following: model number, location, and design flow capacity, contact name, and phone number.

d. Warranty.

e. Information on equipment field erection requirements including total weight of assembled components and weight of each subassembly.

f. Installation and storage instructions.

g. Recommended spare parts.

h. Wiring diagrams.

i. A maintenance schedule showing the required maintenance, frequency of maintenance, lubricants, and other items required at each regular preventive maintenance period.

j. A bill of materials for all equipment, tagged devices, components, special tools, and spare parts supplied with the system, including component original part numbers identifying each furnished component and corresponding to the number provided on the drawings.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications

1. Manufacturer shall have a minimum of twenty years of experience producing equipment substantially like that required and shall be able to submit documentation of at least fifteen independent installations using the same size or larger equipment as detailed below. At the time of submission, each installation must have been in satisfactory operation for at least five years.

2. The Contract Documents represent the minimum acceptable standards for the equipment. All equipment shall conform fully in every respect to the requirements of the respective parts and sections of the Drawings and Specifications. The entire unit shall be Manufacturer's standard product, but shall be modified, redesigned, furnished with special features or accessories, made of materials, or provided with finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of the Specification.

3. Fabrication shall be done in compliance with all applicable ASTM standards or equivalent international standards.

4. All materials and equipment specified herein shall be within the scope of Underwriter's Laboratories (UL) Examination Services, be approved by the UL for the purpose for which they are used and shall bear an NRTL label.

1.5 WARRANTY

A. All warranty provisions shall begin at the date of Substantial Completion. A copy of each warranty shall be provided to the Owner with vendor's O&M Manual.

B. The pump manufacturer shall warrant the pump, motor and guide system to the Owner against defects in workmanship and materials for a period of five years under normal use and service. If a guide cable system is used the pump manufacturer shall warrant the guide cable system (including guide cables and brackets) to the Owner against defects in workmanship and materials for a period of ten years under normal use and service. Both pump manufacturer warranties shall be in published form and shall apply to all similar units.

C. The warranty shall include all work required to remedy the situation, including but not limited to initial on-site review, removal, reinstallation, freight, startup, testing, calibration, etc.

D. Include coverage of all bearings, seals, wear plates, and accessories for a minimum of one year from the date of Substantial Completion and prorated for a period of five years from the date of Substantial Completion.

E. Warrant all equipment provided under this section, regardless of whether it is manufactured by the pump manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the pump supplier shall service the pumps and motors.

PART 2 PRODUCTS

2.1 BASIS OF DESIGN

A. Manufacturer used as the basis of design: Wilo USA LLC

B. Model: EMU FA25.31Z with motor FK202-6/27

C. The manufacturer's representative is:

Brooks Proch

Ambiente H2O, Inc.

(720) 450-2523

bproch@ambienteh2o.com

D. Alternate manufacturers may not participate in bidding as "or equals" only if pre-approved. Review as an "or equal" for pre-approval shall be in accordance with the procedures outlined in the General Conditions Article 7.05. Manufacturers listed

below (as applicable) must meet or exceed this Technical Specification and related sections.

1. Pre-approved "or equals" are as follows:

   a. None

2. Manufacturers seeking to be listed as pre-approved shall provide a complete submittal for review by ENGINEER a minimum of 15 days prior to bid opening.

E. Substitution requests will not be reviewed during bidding.

2.2 GENERAL

A. The pumping units shall all be supplied by one manufacturer and shall be complete including submersible pump for vertical dry installed and motor, discharge elbow, mechanical seals, and related and required accessories.

B. Pumping units shall be designed for the performance and design requirements as shown in the Contract Documents.

2.3 DESIGN REQUIRMENTS

Quantity	2
Free Passage Max Size	4.9 inches
Minimum Flow	927.5 gpm
Design Point #1 (primary design point)	2750 gpm @ 15.9 ft TDH and 60 hz
Design Point #2	927.5 gpm @ 31.44 ft TDH and 60 hz
Design Point #3	3392.5 gpm @ 11.65 ft TDH and 60 hz
Fluid Temperature	68 degrees Fahrenheit
Drive Type	VFD
Motor Power	20 hp
Maximum Motor Speed	1200 rpm
Motor Voltage	460 volts
Discharge	10 inch
Suction	8 inch
Impeller Diameter	10.31 inches
Minimum Efficiency	60%

2.4 EQUIPMENT DESCRIPTION

A. MATERIALS

1. Submersible Sewage Pumps

   a. Volute: Cast Iron, ASTM A48, Class 30B (GG20)

b. Motor Housing: Cast Iron, ASTM A48, Class 30B (GG20)

c. Impeller: Cast Iron, ASTM A48, Class 30B (GG20)

d. Discharge Base Elbow: Cast Iron, ASTM A48, Class 30B

e. Pump/Motor Shaft: AISI 420 (1.4021)

f. Shaft Sleeve: Stainless Steel, ASTM A276 Type 420 (1.4021)

g. Wear Ring, case: Stainless Steel, AISI 304 (1.4308)

h. Wear Ring, impeller: Stainless Steel, AISI329, (1.4462)

i. O-Rings: FPM (Viton)

j. Lower Seal Faces: Silicon Carbide

k. Upper Seal Faces: Silicon Carbide

l. Lifting Chain or cable: Stainless Steel, AISI 316

m. Oil-all uses (seal lubrication, etc): Ecologically safe, paraffin or mineral base

B. Accessories

1. Power Cable

a. The power cables entering the motor housing shall connect to individual terminal pins, which separates the incoming service from the pump motor.

2. Temperature Protection

a. Refer to Motor section 2.5.A.7 and 2.5.A.8 for information on temperature protection.

3. Seal Leak Detection

a. Provide a detector in the motor's stator cavity which allows a control panel mounted relay to indicate leakage into the motor. Electronic probes which depend on sensing resistance value changes in seal oil will not be acceptable as seal leak indicators.

C. General

1. The sewage pumping units shall be vertical, non-clogging, centrifugal sewage pumps with bottom inlet and side discharge. The pumps shall be direct driven by integral squirrel cage, electric induction motors.

Each pump shall include quick removal system, anchor bolts and all accessories specified herein.

D. Volute

1. Suction and discharge flanges shall be 125# and meet ANSI standard B16.1.

2. All nuts, bolts, washers, and other fastening devices supplied with the pumps shall be stainless steel.

3. All mating surfaces requiring a watertight seal shall be machined and fitted with O-rings. Paper gaskets are not acceptable.

E. Impeller

1. Pump impellers shall be of the solids handling non-clog type. The impeller vane shall be a maximum of 2-vane and shall have a smooth, finished throughout, and shall be free from sharp edges.

2. Impellers shall be key driven and securely held to the shaft by a streamlined impeller washer and bolt assembly specifically designed to reduce friction in the suction eye of the impeller. The arrangement shall be such that the impeller cannot unscrew or be loosened by torque from either forward or reverse rotation. Designs based on threaded connection between pump shaft and impeller will not be considered.

F. Wear Rings

1. The impeller shall be provided with a wear ring that is drive fitted to the suction eye of the impeller.

2. The casing shall be provided with a wear ring that is drive fitted to the bottom suction inlet.

2.5 MOTORS

A. Submersible Motors

1. Each pump shall be furnished with a squirrel cage, induction motor enclosed in a watertight housing suitable for use and compatible with all variable frequency drive systems.

2. The motor shall be suitable for dry-pit or wet-pit installation under full load conditions. Motors shall be certified for variable frequency drive systems without de-rating the motor output power. The motors shall

be capable of installation in either the dry-pit or wet-pit installation without adding or removing any items to the motor's interior or exterior.

3. The motor shall be oil-filled and constructed with moisture resistant NEMA Class H insulation and Class H slot liners and constructed to NEMA B design standards. The copper wound stator shall be dipped in epoxy enamel and hardened to withstand a temperature of 180° C for Class H as defined in NEMA Standard MG-1. Each winding phase or layer shall be laced with Class H glass lined paper. The use of cable ties to restrain windings shall not be allowed. The rotor shall be statically and dynamically balanced after fabrication. The rotor shall utilize aluminum amortisseur bars and short circuit rings. The motor shall be certified for continuous duty with a service factor of 1.10 and shall be non-overloading over the entire acceptable operating range of the impeller.

4. The motor shall be capable of sustaining 15 starts per hour at a minimum ambient temperature of 40°C.

5. The motor shall be capable of uninterrupted operation with a voltage drop of 10%.

6. The power cables entering the motor housing shall connect to individual terminal pins, which separates the incoming service from the pump motor.

7. The motor shall be cooled via the internally circulated oil by means of a pump/motor shaft mounted oil circulation impeller. The oil/coolant impeller shall be mounted above the upper mechanical seal. Systems that utilize a coolant impeller mounted between the upper and lower mechanical seals shall not be acceptable. The motor/pump oil circulation impeller shall cause the oil to move through and around the stator windings and motor rotor from which it picks up heat. This heat is then directed into the motor heat exchanger that transfers the heat to the pumped liquid. The heat exchanger shall be located below the sealing chamber. It shall be provided with a labyrinth design channel system such that a minimum of 85% of the heat generated by the motor must be conducted through the heat exchanger to the pumped liquid. Cooling systems requiring a separate, clean water source or that circulates the pumped sewage through a cooling jacket will not be accepted.

8. Thermal switches shall be furnished to monitor stator temperatures. The stator shall be equipped with three (3) thermal switches. Thermal switches shall automatically de-energize the motor when its temperature exceeds a preset limit as recommended by the manufacturer.

9. The pump manufacturer's nameplates shall be engraved, laser etched, or stamped on stainless steel and fastened to the motor casing.

B. Shafts

1. All shafts shall be dynamically balanced and shall be one-piece construction without joints or stubs attached.

2. Multiple row lower bearings for axial thrust and a single row upper bearing for radial thrust shall support the motor/pump shafts. Thrust bearings shall be restrained from thrust in both directions. Designs that do not protect the pump/motor from thrust in reverse directions shall not be acceptable.

3. Bearings shall be sealed and grease lubricated.

4. Minimum shaft diameter shall be 2.125-in at the lowest bearing.

5. Shaft overhang ratio L3/D4 shall not exceed 10.

C. Mechanical Seals

1. Each pump shall be provided with double mechanical seals with the seal housing constructed of AISI 420 series (1.4028) stainless steel and the spring system constructed of AISI 301 series (1.4310) stainless steel. The block seal housing shall be constructed such that it can be dismantled allowing the seal faces and springs to be renewed and the seal system to be placed back into service. Cartridge seals constructed such that they cannot be repaired or renewed shall not be acceptable.

2. The seal shall be mounted in a separate and isolated seal chamber. The seal chamber shall be filled with non-conductive lubricating oil as recommended by the manufacturer.

3. A moisture sensor shall be furnished to sense moisture intrusion for each pump. This sensor shall be wired to the Pump Control Panel and shall activate an alarm light upon moisture intrusion. The sensor probe shall be mounted in the seal chamber and shall be of the conductive type, sensing moisture intrusion above the lower seal, but below the upper seal. Designs that sense moisture intrusion above the upper seal using a float switch are not acceptable.

D. Power and Control Cables

1. Power and control cables shall be furnished in lengths to run un-spliced from the pump to the pump control panel as shown on the Contract Drawings and as specified herein (40-ft). Cables shall terminate with conductor sleeves that bundle the entire group of

strands of each phase to improve termination at the pump control panel. The sleeves shall be provided to confirm that all strands of each conductor are terminated properly. Termination shall be coordinated with the connection to the Pump Control Panel.

2. Cables shall be of the "NSSHOU" type and shall be approved by the MSHA for use in hazardous locations and shall conform to industry standards for loads, resistance under submersion against sewage, and be of stranded construction. The cables shall enter the pump through a heavy-duty galvanized cast iron entry assembly that shall be provided with an external clamp assembly to protect against tension once secured providing a strain relief function as part of standard construction.

3. The cables for each pump shall pass through the galvanized cast iron strain relief component and then through a series of stainless steel disks and Buna-n grommet that is sandwiched between the disks to control compression of the grommet. These components shall work to compress the cable jacket by the inner diameter of the grommet while the outer diameter of the grommet seals against the inside surface of the cable entry chamber in the top of the motor.

2.6 REMOVAL SYSTEM

A. General Description

1. The removal system shall consist of a discharge base elbow that mounts in the bottom of the pit, a replaceable pump coupling, supports and hardware as required for a complete and operational system. Connections to piping shall be standard ANSI flanges.

B. Discharge Base Elbow

1. The discharge base elbow shall be provided to support the full weight of the submersible pump in the installation and provide a leak proof connection in which the pump coupling mates using a conformed Buna-N seal that is held in place by the combined weight of the cantilevered pump and motor. The hydraulic pressure generated while the pump is in operation also aids the sealing. The discharge base elbow shall be provided guide pipe retention lugs.

C. Pump Coupling

1. The pump coupling shall be close-grained gray cast iron construction. The coupling shall be located between the pump discharge flange and the vertical face of the discharge base. The purpose of the coupling shall be to allow use of a standard ANSI drilled pump-casing flange on the pump. The coupling acts as the intermediate part between the pump and the discharge base. The coupling vertical face is designed

to seal against the vertical face of the discharge base using a replaceable Buna-N elastomeric compressible one-piece seal that acts as both the discharge face seal and the gasket between the coupling and the pump flange. Wet pit installation designs that utilize the flat face of the pump flange to seal against the discharge base are not allowed.

D. Lifting Device

1. A lifting chain of 25-ft shall be provided for each pump. Additional lifting devices, if required, shall be provided by the supplier of the hoist/crane. The responsibility to determine compatibility of the lifting chain with the hoist/crane is by the supplier of the hoist/crane.

2.7 SPARE PARTS AND SPECIAL TOOLS

A. All spare parts shall be properly protected for long-term storage and packed in containers which are clearly identified with indelible markings on the outside as to contents. The Vendor shall furnish as part of the system the following spare parts and safety equipment:

1. One set of any specialized tools required for maintenance or adjustment of the equipment.

2. All spare parts and safety equipment are to be separately packaged. All packages are to have with quantity, item description and part number.

2.8 LUBRICANTS

A. The Contractor shall provide all necessary oils, lubricants, grease guns, or other necessary applicators and shall lubricate the mechanical equipment prior to initial operation in accordance with the manufacturer's requirements and recommendations. The Contractor shall supply a 12-month supply of each lubricant.

2.9 SHOP PAINTING

A. Primer and Finish Paint – Shop apply to all exterior ferrous surfaces of the pump and motor a single coat (6 – 8 mils DFT) of two-component epoxy. Coating shall be resistant to sewage of normal pH and contain no more than 3.5 pounds per gallon of VOCs. Paint color to match existing pumps.

B. Surface Preparation – Prepare all surfaces to receive coating system. Surfaces must be free from dust, grease, rust, scale, and other coatings.

PART 3 EXECUTION

3.1 PRODUCT DELIVERY, HANDLING AND STORAGE

A. Reference Section 01 60 00 Product Requirements and 43 05 10 Equipment General Provisions for additional requirements.

3.2 FACTORY TESTS

A. The Manufacturer's proposed factory testing protocol shall be submitted to the Engineer for review 14 calendar days prior to the anticipated start date of factory testing.

B. Each actual pump and motor, including motor cables, to be supplied on the project shall be non-witnessed factory tested for discharge flow, discharge head, horsepower, and efficiency.

C. Perform hydraulic factory testing of each pump verifying performance and conformance with the specified design conditions. As a minimum, data shall include discharge flow, discharge head, voltage, amperage, and motor speed.

D. Each pump shall be tested in accordance with the latest test code of the Hydraulic Institute (H.I.) at the manufacturer to determine head vs. capacity and kilowatt draw required. Witness tests shall be available at the factory upon request by the Engineer.

E. Impeller, motor rating and electrical connections shall be checked for compliance with this specification.

F. Motor and cable insulation shall be tested for moisture content or insulation defects.

G. Upon request, a written quality assurance record confirming the above testing/inspections shall be supplied with each pump at the time of shipment.

H. Factory test reports shall be submitted to the Engineer for review 14 calendar days prior to the anticipated ship date.

3.3 INSTALLATION

A. Reference Section 01 60 00 Product Requirements for additional requirements.

B. Provide anchor bolts in accordance with Section 43 05 10 Equipment General Provisions.

C. Contractor shall coordinate equipment, motors, drives, and controllers so that the completed system operates satisfactorily under all operating conditions.

D. The Contractor shall lubricate the mechanical equipment prior to initial operation.

3.4 COMMISSIONING

A. Initial Starting and Testing of Systems

1. Reference Section 01 75 16 – Starting Procedures for additional requirements.

2. Reference Section 43 05 10 Equipment General Provisions for additional field testing requirements.

B. Training

1. Reference Section 01 75 16 – Starting Procedures for training requirements.

C. Owner Programming

1. Reference Section 01 75 16 – Starting Procedures for Owner's programming period requirements.

D. Acceptance Testing

1. Reference Section 01 75 16 – Starting Procedures for acceptance testing requirements.

2. The pump manufacturer shall analyze the complete pump and piping system and recommend such supports and modifications as necessary to eliminate harmonics and vibration in the system when operated over the operational speed range. Pump bases and foundations, as well as piping and shaft supports as shown on the plans shall be modified and enlarged as necessary to provide adequate support and vibration control.

3. The installed pumping units shall operate without excessive vibration. Balance of rotating parts shall be maintained throughout the pumps rated performance curve, which will include shutoff points. Vibration amplitude shall not exceed Hydraulic Institute limits, at any operating point along pump curve. If requested by Engineer, Contractor shall provide for an independent vibration analysis at no cost to the Owner to verify vibration requirements are met. Contractor shall be responsible to make required adjustments to ensure vibration is less than the maximum allowable amount. Excessive vibration will be defined as that which exceeds the limits outlined by the Hydraulic Institute.

4. Perform hydraulic field testing for each pump verifying performance on the pump curve. Data shall include flow measurement and discharge pressure at three different operating points for each pump at full speed (60 hz), 90% (54 hz), and 75% (45 hz) (or other speeds as

determined in the field by Engineer). Data shall also include voltage, amperage and motor speed for each pump taken at each of the recorded operating points.

E. If the equipment does not meet the requirements of this Specification, corrective measures shall be taken, and re-testing undertaken to confirm compliance with the Contract Documents at no additional cost to the Owner.

F. Manufacturer's Representative Requirements for On-Site Support and Assistance

1. Manufacturer's representative shall provide the following minimum number of trips, days, and hours onsite for the activities noted below. Note: one day is defined as a minimum of eight hours on-site.

Description	Minimum Number of Trips	Minimum Number of Days Per Trip
Installation Assistance	1	1
Initial Starting and Testing of Systems	1	1
Training	Note 1	Note 1
Initial Acceptance Testing	Note 1	Note 1
Final Acceptance Testing	1	1

a. NOTE 1: Initial Starting and Testing of Systems, Training, and Initial Acceptance Testing could potentially occur within the same trip.

i. Several activities may be grouped together if a minimum advanced notice of 24-hours is provided and Owner's staff and Engineer's staff are available.

2. Contractor's schedule, the progression of the Work, manufacturer's performance, and other factors within Contractor's control may require additional days and/or trips to complete the Work. If, in the opinion of the Engineer, additional time is required to assist with any activity, it shall be provided at no additional cost to the Owner.

END OF SECTION

SECTION 43 30 00
HYDRAULIC PROCESS VALVES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnishing and installing valves as shown and specified. In addition, valve-operating units, stem extensions and other accessories shall be furnished and installed by the Contractor where shown, or where required in the opinion of the Engineer, to provide for convenience in operation. Where buried valves are indicated, the Contractor shall furnish and install valve boxes to grade per the Standard Details – see Drawings. All valves shall be new and of current manufacture.

B. Not all valves and operators listed in this section are used in this project.

1.2 RELATED SECTIONS

A. Section 09 90 00 – High Performance Coatings

B. Section 40 06 00 – Pipe and Fittings

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Shop drawings of all valves and operators, including wiring diagrams and electrical data, shall be furnished as specified in Section 01 33 00.

C. Submit manufacturer's installation instructions and maintain copy at job site.

D. Project Record Drawings: Record actual locations of valves, operators, and accessories.

E. Service: Valve shall be suitable for the specific service conditions, (e.g., raw sewage, sludge, specific chemical, potable water, and etc.). Submit product information verifying valve is compatible with intended service conditions.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 01 73 00.

B. Maintenance Data: Include installation and maintenance instructions, recommended spare parts lists, and exploded view of valves, gates, operators, and accessories.

1.5 QUALITY ASSURANCE

A. Manufacturer's name and pressure rating marked on valve body.

B. Perform work in accordance with manufacturer's recommendation.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products at job site under provisions of Section 01 60 00.

B. Accept valves, operators, and accessories in shipping containers with labeling in place in accordance with American Water Works Association (AWWA) C-501. Inspect for damages.

C. Seal valve ends and gate ends to prevent entry of foreign materials.

1.7 TAGS AND IDENTIFICATION

A. Permanent tags shall be provided for every valve, instrument and gate.

1.8 DEFINITIONS

A. Abbreviations used in Detailed Valve Specification Sheets:

ARV-Air Release Valve
BV- Ball Valve
BFV - Butterfly Valve
CV- Check Valve
CS- Corporation Stops
CB - Circuit Balancing Valve
DPV – Diaphragm Valve
FLV-Flap Valve
GL- Globe Valve
GV- Gate Valve
KGV-Knife Gate Valve
MV - Mud Valve
NV - Needle Valve
PRV-Pressure Regulating Valve
PIV-Pinch Valve
PV - Plug Valve
SGV – Shear Gate Valve
SV – Solenoid Valve

PART 2 PRODUCTS

2.1 GENERAL

A. Unless otherwise specified, each valve body shall be tested under a test pressure equal to twice its design water-working pressure.

B. Unless otherwise specified, all interior bronze parts of valves except gate valve stems shall conform to the requirements of the “Specification for Composition Bronze or Ounce Metal Castings,” (ASTM B62). Gate valve stems shall be of bronze containing not more than five percent of zinc nor more than two percent of aluminum, and shall have a minimum tensile strength of 60,000 pounds per square inch (psi), a yield strength of 40,000 psi, and an elongation of at least 10 percent in two inches, as determined by a test coupon poured from the same ladle from which the valve stems to be furnished are poured.

C. The flanges of valves may be raised or plain faced. Flanges of valves for water-working pressures of 175 psi or less shall be faced and drilled to 125-pound American Standard

template. Flanges of valves for water-working pressures greater than 175 psi shall be faced and drilled to 250-pound American Standard template.

D. Valve Operators:

1. Unless otherwise shown or specified, manual handwheel operators, with position indicators, shall be provided for 6-inch valves and larger. Lever operators may be supplied on quarter-turn-type valves smaller than six inches; however, operator force shall not exceed 40 pounds under any operating condition, including initial breakaway.

2. Operators of the worm-and-gear-type shall have self-locking worm gears. The operators on quarter-turn-type valves shall be of the self-locking-type to prevent the plug or disc from creeping, and shall be provided with position indicators to show the position of the plug or disc. Lever-type operators on exposed valves shall have some means of being fixed in any position to prevent movement.

3. Buried operators on valves larger than two inches shall have a 2-inch AWWA operating nut. Buried operators on valves 2-inch and smaller shall have a T-handle for operation by forked key, unless otherwise shown or specified.

4. All buried valves shall be installed with valve boxes. When the valve centerline is more than four feet below the finished grade, extension stems are required.

E. All moving parts of buried valves and operators shall be enclosed in the housing to prevent contact with the soil.

F. Unless otherwise shown or specified, all exposed nuts, bolts, washers, and springs shall be stainless steel.

G. Where designated, certain valves shall be furnished with electric operators provided by the valve manufacturer. All operators of a given type shall be furnished by the same manufacturer. Where these operators are supplied by different valve manufacturers, the Contractor shall coordinate their operator selections to provide uniformity of each type of electric operator.

H. Unless specifically required to be equipped with other types of operators, all valves with centerline more than 6 feet above the operating floor shall be equipped with chain wheels and operating chains. Each chain-wheel-operated valve shall be equipped with a chain guide that will permit rapid handling of the operating chain without “gagging” of the wheel. Lever operated valves shall be provided with operating chains.

I. Valves and operators in particular locations may require a combination of units, sensors, limit switches, and controls specified in other divisions of these Specifications. It shall be the responsibility of the Contractor to properly assemble and install these various items so that all systems are compatible and operating properly. The relationship between interrelated items shall be clearly noted on shop drawing submittals.

J. Strainer shall be provided ahead of any electric solenoid control valves and regulators.

K. Valve Boxes: Valve boxes, except those noted as special design required on the Drawings, shall be of cast iron of the two-piece extension-type with cast iron cover. The extension shall provide for the maximum depth of cover over the pipe in which the valves are to be used. Valve boxes shall have walls not less than 3/16-inch thick at any point, and the internal diameter shall be not less than five inches. Valve box covers shall have the word "SEWER" or "WATER" cast into them as appropriate to their place of use. All valves underground shall be installed with valve boxes.

L. Miscellaneous Valves: Where indicated on the Drawings, but not specifically identified, Contractor shall furnish and install miscellaneous valves per this specification. Valves shall be high quality and suitable for the indicated service, and approved by the Engineer.

2.2 VALVE DATA PRODUCT INFORMATION SHEETS

A. Individual data sheets for each valve type are included following this section.

PART 3 EXECUTION

3.1 INSTALLATION

A. All valves shall be installed in accordance with good trade practices and the manufacturer's instructions and recommendations.

B. Unless otherwise indicated on the Drawings, all valves installed in horizontal pipe runs having a centerline elevation four foot six inches or less above the finished floor shall be installed with their operating stem vertical. If adjacent piping prohibits this, the valves shall have their operating stems orientated to facilitate the most practical operation. Valves installed in horizontal pipe runs having a centerline elevation greater than four foot six inches above the finished floor shall be installed with their operating stems horizontal. If adjacent piping prohibits this, the stems shall be installed above the valve horizontal centerline as close to horizontal as possible. Valves installed in vertical runs of pipe shall have their operating stems orientated to facilitate the most practicable operation.

C. Provide all necessary fittings to install valve at the location shown in the Plans.

D. All plug valves installed in sludge lines shall be installed with the seat on the upstream side.

3.2 PAINTING

A. All valves unless otherwise specified, shall be painted in accordance with Section 09 90 00.

1. The exterior surfaces of all interior and submerged valves shall be epoxy coated with three to five MDFT of epoxy-polyamide primer in preparation for coating, as specified in Section 09 90 00.

B. All buried valves shall be coated with the manufacturer's fusion bonded epoxy, suitable for buried service.

3.3 TESTING

A. All equipment shall be tested in accordance with Section 46 and Section 40 06 00 as part of a completed system.

B. Valves shall be tested at the same time that the adjacent pipeline is tested. Joints shall show no visible leakage under test.

Table of Contents – Valve Types

Air Release Valve

TYPE OF VALVE		**SYMBOL**	
Air Release Valve		ARV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**ITEM**	**ITEM**	**ITEM**
Shell	Cast Iron ASTM A536	**Type of Service**	Water (Note 2)
Body/Base	Reinforced Nylon (A.R.I.) Cast Iron (GA)	**Reference Document**	AWWA C512
Discharge	Brass ASTM B-124	**Size Range**	½" to 1"
Seals	EPDM	**Body/Valve Ends**	NPT
Float	Foamed Polypropylene	**Pressure Rating (psi)**	10 to 150 (GA) 3.0 to 250 (A.R.I.)
O-Ring	Buna-N	**Temperature Rating (deg C)**	60 C
Bolts/Screws	Stainless Steel	**Testing**	
Strainer	Nylon	**Operator**	NA
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
2. Suitable for venting small amounts of air under normal service conditions.			
3. Provide all necessary fittings and isolation to install the valve at the location shown in the plans.			
ACCEPTABLE PRODUCTS			
A.R.I. S-050-C	GA Industries Figure 905		

Air Release Valve

TYPE OF VALVE		**SYMBOL**	
Combination Air Vacuum / Release Valve		ARV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS (Note 1)**	**Type of Service**	Water (Note 2)
Shell	Stainless Steel	**Reference Document**	AWWA C512
Body/Base	Stainless Steel	**Size Range**	1/2" to 2"
Discharge	Polypropylene	**Body/Valve Ends**	NPT
Seals	EPDM	**Pressure Rating (psi)**	3 to 250
Float	Foamed Polypropylene	**Temperature Rating (deg C)**	
O-Ring	Buna-N	**Testing**	
Bolts/Screws	Stainless Steel	**Operator**	NA
Strainer	None	**Actuator**	NA

NOTES

1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.
2. Suitable for venting air and protection from vacuum under normal service conditions.
3. Provide all necessary fittings and isolation to install the valve at the location shown in the plans.
4. Install the combination air release/vacuum valve on the discharge piping as shown in the plans to rid the piping of entrapped air during normal operating conditions and allow air to exit/enter the piping during filling/emptying conditions.

ACCEPTABLE PRODUCTS

A.R.I. D-040-ST-ST		

Air Release Valve

TYPE OF VALVE		**SYMBOL**	
Combination Air Vacuum / Release Valve		ARV-3	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Sewage (Note 1)
Shell	No Shell	**Reference Document**	AWWA C512-15
Body/Base	316 SS	**Size Range**	2" to 4" (Note 3) 2" to 8" (Note 4)
Discharge	Polypropylene	**Body/Valve Ends**	NPT or FL per plans
Seals	EPDM	**Pressure Rating (psi)**	1.0 to 150 (Note 3) 3.0 to 250 (Note 4)
Float	Foamed Polypropylene	**Temperature Rating (deg C)**	60 C
O-Ring	Buna-N	**Testing**	
Bolts/Screws/Springs	Stainless Steel SAE 316	**Operator**	NA
Strainer	None	**Actuator**	NA

NOTES
1. Install the combination air release/vacuum valve on the discharge piping as shown in the plans to rid the piping of entrapped air during normal operating conditions and allow air to exit/enter the piping during filling/emptying conditions.
2. Provide all necessary fittings and isolation to install the valve at the location shown in the plans
3. 2" to 4", reduced height unit, 1.0 to 150 psi
4. 2" to 8", full height unit, 3.0 to 250 psi

ACCEPTABLE PRODUCTS		
A.R.I. D-025 (Note 3)	A.R.I.-D-026 (Note 4)	GA Industries 842 SS

Example sizing chart:

A.R.I. D-26 Combination Valve Sizing Chart			
	Maximum Flow Rate (A, B)		
Nominal Valve Size (in)	**(cfs)**	**(cfm)**	**(gpm)**
2	8	500	3,740
3	17	1,000	7,481
4	33	2,000	14,961
6	83	5,000	37,403
8	183	11,000	82,286
(A) Maximum flow rate is the maximum orifice flow rate anticipated through a broken process pipe at the lowest point (elevation) in system. Orifice size is assumed to be either ½ or 1/3 of nominal pipe diameter.			

(B) When filling or draining process pipeline.

(C) Submit manufacturer sizing chart for alternative valve selections.

Air Release Valve

TYPE OF VALVE		**SYMBOL**	
Air Release Valve		ARV-4	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Sewage (Note 1)
Shell	N/A	**Reference Document**	AWWA C512
Body/Base	Reinforced Nylon	**Size Range**	2”
Discharge	Polypropylene	**Body/Valve Ends**	NPT or FL per plans
Seals	EPDM	**Pressure Rating (psi)**	3 to 150
Float	Foamed Polypropylene	**Temperature Rating (deg C)**	60 C
O-Ring	Buna-N	**Testing**	
Bolts/Screws/Springs/Stems	Stainless Steel SAE 316	**Operator**	NA
Strainer	None	**Actuator**	NA
NOTES			
1. Suitable for venting air small amounts of accumulated air under normal service conditions.			
2. Provide all necessary fittings and isolation to install the valve at the location shown in the plans.			
ACCEPTABLE PRODUCTS			
A.R.I. S-025			

Air Release Valve

TYPE OF VALVE		SYMBOL	
		ARV-5	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**ITEM**	**ITEM**	**ITEM**
Shell		**Type of Service**	Chemical
Body/Base	PVDF	**Reference Document**	AWWA C512
Discharge	Polypropylene, PVDF	**Size Range**	½" to 2"
Seals	Viton	**Body/Valve Ends**	NPT
Float	Foamed ASA	**Pressure Rating (psi)**	3.0 to 250 (A.R.I.)
O-Ring	Viton	**Temperature Rating (deg C)**	60 C
Bolts/Screws		**Testing**	
Strainer		**Operator**	NA
NOTES			
4. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
5. Suitable for venting air and protection from vacuum under normal service conditions.			
6. Provide all necessary fittings and isolation to install the valve at the location shown in the plans.			
ACCEPTABLE PRODUCTS			
A.R.I. D-040			

Ball Valve

TYPE OF VALVE		**SYMBOL**	
Ball Valve		BV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Air or Water
Body	Bronze	**Reference Document**	
Ball	Hard chrome plated brass ball	**Size Range**	≤2”
Seats	Glass reinforced Durafil or PTFE	**Body/Valve Ends**	NPT, FNPT, Solder as required on drawings with Single Union, union end type
Shaft/Stem	Brass ASTM B16 or SS	**Pressure Rating (psi)**	600 pound WOG
Elastomers		**Temperature Rating (deg C)**	200 °F
Seals	PTFE	**Testing**	
		Operator	Lever Handle-and with screwed ends; 2” Nut (Buried Service)
		Actuator	Manual, lever type
NOTES			
1. Bronze Valves shall be used in copper pipe lines. Valves shall be NSF 61 Certified for Potable Water application–Lead free.			
ACCEPTABLE PRODUCTS			
Watts Series B-6000	Mueller	Apollo 70LF-100 / 200	

Ball Valve

TYPE OF VALVE		**SYMBOL**	
Ball Valve		BV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Air, Water, Process Water
Body	SS	**Reference Document**	
Ball	SS	**Size Range**	<3”
Seats	Teflon	**Body/Valve Ends**	NPT, FNPT, Solder as required on drawings with Single Union
Shaft	SS	**Pressure Rating (psi)**	600 pound WOG
Elastomers		**Temperature Rating (deg C)**	
		Testing	
		Operator	Lever Handle
		Actuator	

NOTES

1. SS Valves shall be used in SS pipe lines. Valves shall be NSF 61 Certified for Potable Water applications -Lead free.
2. Ball valve must have a union fitting, lockable handle, and imprinted tagging.

ACCEPTABLE PRODUCTS

Watts	Mueller	Apollo 76F-100 / 200
	Swagelok Series 40 (up to ¾”)	

Ball Valve

TYPE OF VALVE		**SYMBOL**	
Ball Valve		BV-3	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Sodium Hypochlorite <15%,(or Chlorine Gas Solution)
Body	PVC Type 1	**Reference Document**	
Ball	PVC Type 1 – ***VENTED PORT BALL***	**Size Range**	<2”
Seats	PTFE Seats	**Body/Valve Ends**	True Union with Socket Weld (Note 1)
Shaft		**Pressure Rating (psi)**	150 PSI
Elastomers	PTFE seats or Viton/FKM	**Temperature Rating (deg C)**	
		Testing	
		Operator	Lever Handle or T Handle
		Actuator	

NOTES

1. Valve shall have threaded double-union body that can be removed from the line without disengaging the end connections
2. Valves for sodium hypochlorite service shall be provided with a vented ball and viton/FKM seals.
3. Valves used for Sodium Hydroxide Service shall have flanged connections

ACCEPTABLE PRODUCTS		
Georg Fischer Type 546	Asahi/America Type-21	Spears Mfg. Company 1839V series
Hayward Flow Control		

Ball Valve

TYPE OF VALVE		**SYMBOL**	
Ball Valve		BV-4	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Water, Process Water, Chemical (Ferric Chloride, Sodium Bisulfite, Aluminum Sulfate, Sodium Hydroxide (Note 2), or Citric Acid
Body	PVC Type 1	**Reference Document**	
Ball	PVC Type 1	**Size Range**	4" and smaller
Seats	PTFE	**Body/Valve Ends**	True Union with Socket Weld (Note 1)
Shaft		**Pressure Rating (psi)**	150 PSI
Elastomers	PTFE Seats, EPDM or Viton/FKM (Note 2)	**Temperature Rating (deg C)**	
		Testing	
		Operator	Lever Handle or T Handle
		Actuator	Electric (when noted)

NOTES
1. Valve shall have threaded double-union body that can be removed from the line without disengaging the end connections
2. When used with sodium hydroxide, valve elastomers shall be PTFE only.

ACCEPTABLE PRODUCTS		
Georg Fischer Type 546	Asahi/America Type-21 (Series 94 electric actuator when noted)	Cabot - Chemtrol True Union (TU) Series
	Hayward Flow Control	Spears Mfg. Company 1829/1839 series (CTQ series electric actuator when noted)

Butterfly Valve

TYPE OF VALVE		**SYMBOL**	
Butterfly Valve		BFV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water, Compressed Air; Interior Exposed Mechanical
Body	One piece cast iron or ductile iron body.	**Reference Document**	AWWA C504
Disc	The disc shall be secured to the shaft using at least two Type 316 stainless steel pins or self-locking setscrews. 316 stainless steel disc.	**Size Range**	3" to 30"
Bushings/ Bearings	All valves shall be furnished with two upper bearings/bushings and one lower bearing/bushing of PTFE material **or Nylatron.**	**Body/Valve Ends**	125/150# pattern Lugged Style (Note 2) AWWA Valves to be Flanged
Pins	Stainless Steel.	**Pressure Rating (psi)**	150 PSI Liquid, Air or Vacuum Service for AWWA Valves, Bi-Directional "dead end" or 175 psi with directional (with disc)/100 psi (against disc) "dead end" bubble tight shutoff capability without the use of backing flanges.
Shaft/ Stem	316 or 416 Stainless Steel. Shaft seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion.	**Temperature Rating (deg C)**	
Seats/ Seals	Valve seats shall be of the reinforced resilient type and shall be field replaceable (in sizes over 24" on AWWA valves). Seats on Lugged Valves shall also act as a body liner to prevent flow from contacting the body casting. Seats on Industrial Valves shall have flange sealing to provide a positive seal without use of flange gaskets. Water Service: EPDM; Compressed Air Service (high pressure): PTFE; Process Air Service (low pressure): Fluorocarbon (Viton, RTFE, or Fluorinated Hydrocarbon Elastomer	**Testing**	Factory Testing shall be conducted on each valve in accordance with Manufacturer's Quality Control procedures.

	ASTM D1418) rated for 350° minimum or higher if required by process.		
Packing		**Operator**	4" Lever Handle, >4" Geared Handwheel /Chainwheel
Backing Ring		**Actuator**	Electric actuators or Pneumatic or Manual as shown on the plans and as specified in Section 15106 and Division 16. (Note 2). Include Manual Override.

NOTES

1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free and AWWA Compliant
2. Valve shall be capable of being installed vertically or horizontally; and have the ability to be installed with the disc in the closed position.

ACCEPTABLE PRODUCTS

Bray Series 30/31	Keystone	Pratt Series BF, 2FII or Triton

Butterfly Valve

TYPE OF VALVE		**SYMBOL**	
Butterfly Valve		BFV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water. Exposed Interior Mechanical Service Automated – Modulating and Cyclic Service (Note 3).
Body	316 Stainless Steel	**Reference Document**	
Disc	316 Stainless Steel	**Size Range**	2" to 30"
Bushings/ Bearings	EPDM or RTFE	**Body/Valve Ends**	125/150# pattern Lugged Style (Note 2)
Pins	316 Stainless Steel	**Pressure Rating (psi)**	150 PSI Liquid, Air or Vacuum Service Bi-Directional. Valves shall provide ANSI Class VI shutoff
Shaft/ Stem	17-4PH stainless steel or 316 stainless steel	**Temperature Rating (deg C)**	
Seats/ Seals	Water Service: EPDM, Teflon; Compressed Air Service (high pressure): PTFE, Teflon; Process Air Service (low pressure): Fluorocarbon (Viton or RTFE or Fluorinated Hydrocarbon Elastomer – ASTM D1418) rated for 300° minimum or higher if required by process	**Testing**	Factory Testing shall be conducted on each valve in accordance with Manufacturer's Quality Control procedures.
Packing	PTFE	**Operator**	4" Lever Handle, >4" Geared Handwheel /Chainwheel
Backing Ring	Stainless Steel	**Actuator**	Electric actuators or Pneumatic as shown on the plans and as specified in Section 15106 and Division 16. (Note 3). Include Manual Override.
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free.			
2. Valve shall be capable of being installed vertically or horizontally; and have the ability to be installed with the disc in the closed position.			

3. Valve shall be suitable for pneumatically or electrically automated in on/off service, modulating, or throttling service and classified as a "High Performance Butterfly Valve," and shall utilize an offset disc design with a soft seat.		
ACCEPTABLE PRODUCTS		
Bray Series 40/41	Keystone	Pratt Series HP

Butterfly Valve

TYPE OF VALVE		**SYMBOL**	
Butterfly Valve		BFV-3	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water with chlorine solution 50 ppm to 1000 ppm. Interior Exposed Mechanical.
Body	One piece cast iron or ductile iron body	**Reference Document**	
Disc	PVDF Coated Disc	**Size Range**	2" to 12"
Bushings/ Bearings	All valves shall be furnished with two upper bearings/bushings and one lower bearing/bushing of PTFE material. Shaft seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion	**Body/Valve Ends**	125/150# pattern Lugged Style (Note 2)
Pins	Stainless Steel	**Pressure Rating (psi)**	150 PSI Liquid, Air or Vacuum Service Bi-Directional
Shaft/ Stem	316 or 416 Stainless Steel	**Temperature Rating (deg C)**	
Seats/ Seals	Valve seats shall be of the reinforced resilient type and shall be field replaceable. Seats shall also act as a body liner to prevent flow from contacting the body casting. Seats shall have flange sealing to provide a positive seal without use of flange gaskets EPDM or Viton as required by service conditions and chemical exposure. Verify material is suitable for specific chemical exposure.	**Testing**	Factory Testing shall be conducted on each valve in accordance with Manufacturer's Quality Control procedures.
Packing		**Operator**	4" Lever Handle, >4" Geared Handwheel /Chainwheel

Backing Ring		**Actuator**	Electric actuators or Pneumatic as shown on the plans and as specified in Section 15106 and Division 16. (Note 2). Include Manual Override.

NOTES
1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free.
2. Valve shall be capable of being installed vertically or horizontally; and have the ability to be installed with the disc in the closed position.

ACCEPTABLE PRODUCTS		
Bray Series 22/23	Keystone - Resilient Seated Valve Types 920	Pratt Series BF

Butterfly Valve

TYPE OF VALVE		**SYMBOL**	
Butterfly Valve		BFV-4	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water. Buried.
Body	Cast iron (ASTM A-126)	**Reference Document**	AWWA C504
Disc	Ductile iron	**Size Range**	4" to 36"
Bushings/ Bearings		**Body/Valve Ends**	125/150# pattern FL or MJ as shown on the drawings (Note 2)
Pins		**Pressure Rating (psi)**	150 PSI Liquid, Air or Vacuum Service Bi-Directional
Shaft/ Stem	316 stainless steel shaft with o-ring seals	**Temperature Rating (deg C)**	
Seats/ Seals	BUNA-N seal	**Testing**	Factory Testing shall be conducted on each valve in accordance with Manufacturer's Quality Control procedures.
Packing		**Operator**	2" Nut, fully gasketed. Minimum 24 turns from open to closed
Backing Ring		**Actuator**	NA
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free.			
2. Valve shall be capable of being installed vertically or horizontally.			
ACCEPTABLE PRODUCTS			
Pratt – Groundhog	Mueller	Clow BFV 4500 (3" to 24") Clow BFV 1450 (30" to 36")	

Butterfly Valve

TYPE OF VALVE		**SYMBOL**	
Butterfly Valve		BFV-5	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water
Body	PVC or CPVC (Note 3)	**Reference Document**	ANSI B16.10
Disc	PVC or CPVC (Note 3)	**Size Range**	2" to 12"
Bushings/ Bearings		**Body/Valve Ends**	125/150# pattern FL (Note 2)
Pins		**Pressure Rating (psi)**	150 PSI Liquid, Air or Vacuum Service Bi-Directional
Shaft/ Stem	316 stainless steel shaft	**Temperature Rating (deg C)**	
Seats/ Seals	Nitrile liner	**Testing**	Factory Testing shall be conducted on each valve in accordance with Manufacturer's Quality Control procedures.
Packing		**Operator**	
Backing Ring		**Actuator**	NA
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free.			
2. Valve shall be capable of being installed vertically or horizontally.			
3. Body and disc material shall match that of the process pipe on which it is installed.			
ACCEPTABLE PRODUCTS			
Hayward Flow Control			

Check Valve

TYPE OF VALVE		**SYMBOL**	
Swing Check Valve		CV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Liquid (Water or Sewage)
Body	PVC	**Reference Document**	PVC shall conform to ASTM D1784 cell classification 12454
Hardware		**Size Range**	< 8”
Ball		**Body/Valve Ends**	FL (Note 2)
Type of Disc	Swinging Inclined Disc	**Pressure Rating (psi)**	150 PSI
Disc	PVC	**Temperature Rating (deg C)**	
Trim	316 SS	**Testing**	
Packing	EPDM Seals	**Operator**	External SS Spring Assist. Or Lever/weight
Shaft	316 SS	**Actuator**	
Seats	EPDM		
Bonnet	PVC Removable w/ SS hardware		
Elastomers			
Cover			
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
2. Valve shall be capable of being installed vertically or horizontally.			
ACCEPTABLE PRODUCTS			
Asahi/America		Spears Mfg. Company 4423 series	

Check Valve

TYPE OF VALVE		**SYMBOL**	
Swing Check Valve		CV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Liquid (Water or Sewage)
Body	Cast Iron, factory epoxy coated interior	**Reference Document**	AWWA C508
Type of Disc	Swinging Inclined Disc	**Size Range**	4" to 24"
Disc	Cast Iron, epoxy coated	**Body/Valve Ends**	FL or MJ per drawings
Trim	304 SS	**Pressure Rating (psi)**	
Shaft	304 SS	**Temperature Rating (deg C)**	
Seats	Bronze with (NBR) rubber seat ring	**Testing**	
Packing		**Operator**	External SS Spring Assist or Lever and adjustable Weight.
Bonnet	Cast Iron, factory epoxy coated interior	**Actuator**	
Elastomers	NBR rubber	**Installation**	(Note 2)
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
2. Valve shall be capable of being installed vertically or horizontally.			
ACCEPTABLE PRODUCTS			
Mueller	Kennedy	Pratt Series 8001	Golden Anderson (VAG/GA Industries)

Check Valve

TYPE OF VALVE		**SYMBOL**	
PVC Ball Check Valve		CV-3	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Sodium Hypochlorite <15%,(or Chlorine Gas Solution)
Body	PVC Type 1	**Reference Document**	
Hardware		**Size Range**	<2”
Ball	PVC Type 1	**Body/Valve Ends**	Union with Socket Weld (Note 1)
Type of Ball		**Pressure Rating (psi)**	150 PSI
Disc		**Temperature Rating (deg C)**	
Trim		**Testing**	
Packing		**Operator**	
Shaft		**Actuator**	
Seats	PTFE seats or Viton/FKM		
Bonnet			
Elastomers			
Cover			

NOTES
1. Valve shall be capable of being installed vertically or horizontally.
2. The valve shall permit flow in direction only and close tightly, without slamming, when its discharge pressure exceeds its inlet pressure.
3. The valve shall operate without hydraulic shock and require no maintenance.
4. Valve flow area shall be 100% of the nominal pipeline diameter cross sectional area. Valve body interior shall be designed with smooth surfaces with no projections or pockets to trap solid material.

ACCEPTABLE PRODUCTS		
Georg Fischer Type 561	Asahi/America Ball Check	Spears Mfg. Company 4539 series
Hayward Flow Control		

Check Valve

TYPE OF VALVE		**SYMBOL**	
PVC Ball Check Valve		CV-4	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Ferric Chloride, Sodium Bisulfite, Aluminum Sulfate or Citric Acid
Body	PVC Type 1	**Reference Document**	
Hardware		**Size Range**	<2”
Ball	PVC Type 1	**Body/Valve Ends**	Union with Socket Weld (Note 1)
Type of Ball		**Pressure Rating (psi)**	150 PSI
Disc		**Temperature Rating (deg C)**	
Trim		**Testing**	
Packing		**Operator**	
Shaft		**Actuator**	
Seats	PTFE Seats, EPDM or Viton /FKM		
Bonnet			
Elastomers			
Cover			
NOTES			
1. Valve shall be capable of being installed vertically or horizontally.			
ACCEPTABLE PRODUCTS			
Georg Fischer Type 561	Asahi/America Ball Check	Spears Mfg. Company 4529 /4539 series	
Hayward Flow Control			

Check Valve

TYPE OF VALVE		**SYMBOL**	
PVC Ball Check Valve		CV-5	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Sodium Hydroxide (Caustic Soda)
Body	PVC Type 1	**Reference Document**	
Hardware		**Size Range**	<2”
Ball	PVC Type 1	**Body/Valve Ends**	Union with Socket Weld (Note 1)
Type of Ball		**Pressure Rating (psi)**	150 PSI
Disc		**Temperature Rating (deg C)**	
Trim		**Testing**	
Packing		**Operator**	
Shaft		**Actuator**	
Seats	EPDM, PTFE		
Bonnet			
Elastomers			
Cover			
NOTES			
1. No threaded connections shall be permitted.			
ACCEPTABLE PRODUCTS			
Georg Fischer Type 561	Asahi/America Ball Check	Spears Mfg. Company 4529 Series	
Hayward Flow Control			

Check Valve

TYPE OF VALVE		**SYMBOL**	
Ball Check Valve		CV-6	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Sewage Sludge and Solids
Body	Cast Iron (ASTMA126-B) Ductile Iron ASTM A536	**Reference Document**	
Hardware	Stainless Steel Grade 304 or 316	**Size Range**	4" to 24"
Ball	Vulcanized Buna-N (nitrile) rubber cover over hollow metal ball core Ductile Iron ASTM A536, Grade 65-45-12 Vulcanized with Buna-N Rubber	**Body/Valve Ends**	FL per drawings (Note 2), integrally cast 125# inlet and outlet flanges
Type of Ball	Non-Clog, no slam (Note 2)	**Pressure Rating (psi)**	150 PSI
Disc		**Temperature Rating (deg C)**	
Trim	SS	**Testing**	
Packing	Mfr standard	**Operator**	
Shaft	SS	**Actuator**	
Seats	Buna N		
Bonnet		**O-Ring**	Buna-N
Elastomers		**Flanges**	ASME B16.1 Class 125
Cover	Cast Iron (ASTMA126-B) Ductile Iron ASTM A536, Grade 65-45-12		
NOTES			
1. Valve shall be capable of being installed vertically or horizontally.			
2. Valve flow area shall be 100% of the nominal pipeline diameter cross sectional area.			
3. Internal & External Thermosetting Fusion Bonded Epoxy Coating			
ACCEPTABLE PRODUCTS			
AV-TEK Series 4900			

Check Valve

TYPE OF VALVE		**SYMBOL**	
Globe Style Check Valve		CV-7	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1,3)	**Type of Service**	Potable Water
Body	Ductile iron body ASTM A-536 65-45-12	**Reference Document**	-
Type of Disc	Dual guided (top and bottom)	**Size Range**	4" to 24"
Disc	Stainless steel ASTM type 304	**Body/Valve Ends**	FL per drawings (Note 2), 125# ANSI flat face flanges
Guide bushing	304 Stainless Steel	**Pressure Rating (psi)**	150 PSI
Guide pins	Type 304 Stainless Steel	**Temperature Rating (deg C)**	-
Helical or conical spring	ASTM A313 Type 304 Stainless Steel	**Testing**	-
Packing		**Operator**	-
Shaft		**Actuator**	-
Seats	Stainless steel ASTM type 304		
Bonnet			
Elastomers			
Cover			
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
2. Valve shall be capable of being installed vertically or horizontally.			
3. Check valve to have a minimum open area in the body of 110% of the area of the entering or corresponding pipe**.**			
4. Verify the adjacent upstream flange for the adjacent pipe/fitting/valve, internal diameter will adequately support/restrain the check valve internal mechanism within the check valve body. Provide filler flange as necessary.			
ACCEPTABLE PRODUCTS			
Pratt	Milliken	Mueller	Kennedy

Check Valve

TYPE OF VALVE		**SYMBOL**	
Backwater Check Valve		CV-8	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water, Sewage
Body	EPDM	**Reference Document**	
Hardware	SS	**Size Range**	4" to 36"
Ball		**Body/Valve Ends**	FL per drawings (Note 2)
Type of Disc		**Pressure Rating (psi)**	150 PSI, (Note 3)
Disc		**Temperature Rating (deg C)**	
Trim		**Testing**	
Packing		**Operator**	
Shaft		**Actuator**	
Seats			
Bonnet			
Elastomers			
Cover			
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
2. Valve shall be capable of being installed vertically or horizontally.			
3. Valve shall open under 2-inch WC differential pressure.			
ACCEPTABLE PRODUCTS			
Proco 710 (FL) 730 (Plain End)	Red Valve - TideFlex Series 35 or 35-NSF61		

Check Valve

TYPE OF VALVE		**SYMBOL**	
Globe Style Check Valve		CV-9	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1,3)	**Type of Service**	Water
Body	316 Stainless Steel, ASTM A351, GR-CF8M	**Reference Document**	-
Type of Disc	Dual guided (top and bottom)	**Size Range**	4" to 24"
Disc	316 Stainless Steel, ASTM A351, GR-CF8M	**Body/Valve Ends**	FL per drawings (Note 4), 125# ANSI flat face flanges
Guide bushing	316 Stainless Steel	**Pressure Rating (psi)**	150 PSI
Guide pins	316 Stainless Steel	**Temperature Rating (deg C)**	-
Helical or conical spring	ASTM A313 Type 316 Stainless Steel	**Testing**	-
Packing	-	**Operator**	-
Shaft	-	**Actuator**	-
Seats	EPDM		
Bonnet	-		
Elastomers	-		
Cover	-		
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
2. Valve shall be capable of being installed vertically or horizontally.			
3. Check valve to have a minimum open area in the body of 110% of the area of the entering or corresponding pipe**.**			
4. Verify the adjacent upstream flange for the adjacent pipe/fitting/valve, internal diameter will adequately support/restrain the check valve internal mechanism within the check valve body. Provide filler flange as necessary.			
ACCEPTABLE PRODUCTS			
Flomatic	Dezurik		

CORPORATION STOPS

TYPE OF VALVE		**SYMBOL**	
Corporation Stops		CS-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water, Buried.
Body	Bronze	**Reference Document**	AWWA C800
Gasket	EPDM	**Size Range**	¾" to 2"
		Body/Valve Ends	NPT
		Pressure Rating (psi)	300 PSI Liquid, Air or Vacuum Service
		Temperature Rating (deg C)	-
		Testing	Factory Testing shall be conducted on each valve in accordance with Manufacturer's Quality Control procedures.
		Operator	T-head fork handle
		Actuator	-
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free.			
ACCEPTABLE PRODUCTS			
Ford Meter Box Company	Mueller		

Diaphragm Valve

TYPE OF VALVE		**SYMBOL**	
Diaphragm Valve		DPV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Sodium Hypochlorite <15%,(or Chlorine Gas Solution)
Body	PVC Type 1	**Reference Document**	-
Bonnet	PVC Type 1	**Size Range**	<=4”
Elastomers	PTFE seats or Viton/FKM	**Body/Valve Ends**	Union with Socket Weld or FL (Note 1)
Diaphragm Pattern	Saunders pattern EPDM/PTFE 3-layer with PVDF gas barrier	**Pressure Rating (psi)**	150 PSI
		Temperature Rating (deg C)	-
		Testing	
		Operator	Wheel RS, manual
		Actuator	-
NOTES			
1. Valve shall be capable of being installed vertically or horizontally.			
2. Provide with position indicator.			
3. Diaphragm valves shall be installed in all chlorine solution and chemical feed lines, between the appropriate storage tanks and point of application and as located on the Drawings.			
Georg Fischer	Asahi/America Type-14	Hayward Flow Control	

Diaphragm Valve

TYPE OF VALVE		**SYMBOL**	
Diaphragm Valve		DPV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Ferric Chloride, Aluminum Sulfate, Sodium Bisulfite
Body	PVC Type 1	**Reference Document**	
Bonnet	PVC Type 1	**Size Range**	≤ 2 inch
Elastomers	PTFE Seats, EPDM or Viton /FKM	**Body/Valve Ends**	Union with Socket Weld or FL (Note 1)
Diaphragm Pattern	Saunders pattern with PTFE/EPDM depending on service	**Pressure Rating (psi)**	150 PSI
		Temperature Rating (deg C)	
		Testing	
		Operator	Wheel RS, manual
		Actuator	

NOTES
1. Valve shall be capable of being installed vertically or horizontally.
2. Provide with position indicator.
3. Diaphragm valves shall be installed in all chlorine solution and chemical feed lines, between the appropriate storage tanks and point of application and as located on the Drawings.

ACCEPTABLE PRODUCTS		
Georg Fischer	Asahi/America Type-14	Hayward Flow Control

Diaphragm Valve

TYPE OF VALVE		**SYMBOL**	
Diaphragm Valve		DPV-3	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Sodium Hydroxide (Caustic Soda)
Body	PVC Type 1	**Reference Document**	
Bonnet	PVC Type 1	**Size Range**	≤4 inch
Elastomers	EPDM, PTFE	**Body/Valve Ends**	Union with Socket Weld or Flanged (Note 1)
Diaphragm Pattern	Saunders pattern with EPDM/ PTFE depending on service	**Pressure Rating (psi)**	150 PSI
		Temperature Rating (deg C)	
		Testing	
		Operator	Wheel RS
		Actuator	

NOTES
1. No threaded connections shall be permitted.
2. Provide with position indicator.
3. Diaphragm valves shall be installed in all chlorine solution and chemical feed lines, between the appropriate storage tanks and point of application and as located on the Drawings.

ACCEPTABLE PRODUCTS		
Georg Fischer	Asahi/America Type-14	Hayward Flow Control

Flap Valve

TYPE OF VALVE		**SYMBOL**	
Flap Valve		FLV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Liquid (Water or Sewage, Mixed Liquor)
Body/ Flap	Cast iron conforming to ASTM Specifications A126 Class B or Fabricated 304/316 SS	**Reference Document**	-
Hinge Pin	Bronze B62 or 304/316 SS mounts, offset single pivoted hinge, and shall unseat and swing open under unseating pressure. SS	**Size Range**	4" to 24" .
Seat Ring	The flap gate seat ring shall either be rolled into a dove-tailed groove under pressure to make one inseparable unit. The body seat ring shall be threaded and screwed into place in the body. Both gate and body seat ring faces shall be machined to a smooth finish. Bronze B62 or a self-adjusting lip design of EPDM.	**Body/Valve Ends**	ANSI B16.1, Class 125/ANSI B16.5, Class 150 flanges
Wedges/ Seal Faces	Shall bolt on with stainless steel hardware to permit replacement.	**Pressure Rating (psi)**	- As per specification
		Temperature Rating (deg C)	- As per specification
		Testing	- As per specification
		Operator	Handle, with extensions and catch bracket shall be furnished to elevations shown on Plans. As per specifications Orbinox Complies
		Actuator	- As per specification/drawings
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free. Pending			
ACCEPTABLE PRODUCTS			
Kennedy	Clow	M&H	

Orbinox RR or RC		

Gate Valve - Resilient Seat

TYPE OF VALVE		**SYMBOL**	
Resilient Seat Gate Valve		GV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	WOG (Liquid)
Body	Bronze	**Reference Document**	-
Type of Disc	Solid wedge	**Size Range**	<2 ½ inches
Disc	Mfr standard	**Body/Valve Ends**	NPT or FNPT
Trim	Bronze	**Pressure Rating (psi)**	200 WOG operating, 300 design
Packing	Mfr standard	**Temperature Rating (deg C)**	-
Shaft	SS	**Testing**	-
Seats	Mfr standard	**Operator**	Rising Stem
Bonnet	Union	**Actuator**	-
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
ACCEPTABLE PRODUCTS			
Jenkins Bros			

Gate Valve - Resilient Seat

TYPE OF VALVE		**SYMBOL**	
Resilient Seat Gate Valve		GV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1, 3)	**Type of Service**	Liquid
Body	Ductile Iron (Note 2)	**Reference Document**	AWWA C509 and 515
Type of Disc	Full Round Port	**Size Range**	2 to 12 inches
Wedge	Ductile Iron or Cast Iron (Note 2)	**Body/Valve Ends**	FL or MJ per drawings
Trim	Mfr Standard	**Pressure Rating (psi)**	200 operating, 400 design, min.The valve shall seal at full rated pressure with flow from either direction.
Packing	Double O-Ring seal	**Temperature Rating (deg C)**	
Shaft	Mfr Standard	**Testing**	
Seats	Steel Reinforced Rubber, replaceable, or fully encapsulated Rubber	**Operator**	NRS; Handwheel (exposed) or 2-inch square nut (buried).
Bonnet	Mfr Standard	**Actuator**	
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
2. Epoxy coat interior surfaces.			
3. All exposed nuts, bolts and washers shall be zinc-plated. Buries valves shall have stainless steel fasteners.			
ACCEPTABLE PRODUCTS			
Mueller Company 2361 or 2362	Clow 2639 Full Body DI		

Globe Valve

TYPE OF VALVE		**SYMBOL**	
Globe Valve		GL-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Liquid
Body	Bronze, B62	**Reference Document**	-
Type of Disc	Polyurethane, PTFE or (mfr standard)	**Size Range**	<2 ½ inches
Disc	Bronze; composition disc	**Body/Valve Ends**	FNPT, NPT or FL; screwed ends
Trim	Bronze	**Pressure Rating (psi)**	Class 125, 300 lb WOG
Packing	Teflon Impregnated asbestos	**Temperature Rating (deg C)**	3 to 100, design 120
Shaft	Bronze Ring	**Testing**	-
Seats	-	**Operator**	Handwheel, Rising Stem
		Actuator	-
NOTES			
1.			
ACCEPTABLE PRODUCTS			
Jenkins Bros.	Apollo 120T Apollo 127T	Crane	

Needle Valve

TYPE OF VALVE		**SYMBOL**	
Needle		NV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Liquid
Body	316 SS	**Reference Document**	-
Type of Disc	-	**Size Range**	1/8" – 1/2"
Disc	-	**Body/Valve Ends**	FNPT, NPT
Trim	-	**Pressure Rating (psi)**	5000 PSIG
Packing	316 SS Packing Nut	**Temperature Rating (deg C)**	-28 to 37
Shaft	316 SS	**Testing**	-
Seats	-	**Operator**	-
		Actuator	-
NOTES			
ACCEPTABLE PRODUCTS			
Swagelock Series 1R or 18R	Parker		

Knife Gate Valve

TYPE OF VALVE		**SYMBOL**	
Knife Gate Valve		KGV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Liquid (Water or Sewage, Mixed Liquor)
Body/ Frame	304 Stainless Steel ASTM A351 CF8/ or Cast Iron	**Reference Document**	
Disc/ Gate	304 Stainless Steel ASTM A240	**Size Range**	4" to 24"
Yoke	304 Stainless Steel CF8	**Body/Valve Ends**	ANSI B16.1, Class 125/ANSI B16.5, Class 150 flanges; heavy duty flanged type; must provide positive seal under both seating and unseating head conditions.
Trim/ Fasteners	18-8 SS	**Pressure Rating (psi)**	150
Stem/ Stem Nut/ Seat ring	304 Stainless Steel ASTM A276	**Temperature Rating (deg C)**	
Packing	Teflon w/ PTFE anti-extrusion plate 500˚F (260˚C)	**Testing**	
Gland	304 Stainless Steel ASTM A351 CF8	**Operator**	Non-Rising Stem (Note 2); handwheel - or 2" nut
Yoke Sleeve	Aluminum Bronze or Brass	**Actuator**	
Seat	NBR or EPDM		

NOTES

1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.
2. Valves shall be furnished complete with non-rising stainless-steel extension stem and indicating floor stand, or wall bracket, or 2-inch operating nut, depending on location, as shown on the Drawings. Stem guides shall be provided as recommended by the manufacturer.

ACCEPTABLE PRODUCTS		
Dezurik KGN	Red Valve Series D Slurry KGV	Approved Equal
Henry Pratt		

Mud Valve

TYPE OF VALVE		**SYMBOL**	
Mud Valve		MV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Liquid (Water or Sewage, Mixed Liquor)
Body/ Frame	316L Stainless Steel	**Reference Document**	-
Disc/ Gate	316L Stainless Steel	**Size Range**	4”-6”
Yoke	316L Stainless Steel	**Body/Valve Ends**	ANSI B16.1, Class 125/ANSI B16.5, Class 150 flanges; heavy duty flanged type; must provide positive seal under both seating and unseating head conditions.
Trim/ Fasteners	316L Stainless Steel	**Pressure Rating (psi)**	150
Stem/ Stem Nut/ Seat ring	Stem: 316L Stainless Steel Stem Nut: Bronze Seat ring shall be tapered and have a machined seating face that mates with the seat to provide a drip tight seal. Stem threads shall be machined cut modified acme threads.	**Temperature Rating (deg C)**	-
Packing	Bronze to Bronze	**Testing**	-
Plug	Plug: 316L Stainless Steel Plug Seat: Seamless Buna-N	**Operator**	Non-Rising Stem (Note 2); handwheel
Yoke	316L Stainless Steel	**Actuator**	-

NOTES
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.
2. Valves shall be furnished complete with non-rising stainless steel extension stem and indicating floor stand, or wall bracket, or 2-inch operating nut, depending on location, as shown on the Drawings. Stem guides shall be provided as recommended by the manufacturer.

ACCEPTABLE PRODUCTS		
Troy Valve	Trumbull	Waterman Model MV-11

Pressure Regulating Valve

TYPE OF VALVE		**SYMBOL**	
Pressure Regulating Valve (Pressure Reducing)		PRV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Water
Body	Cast Bronze, Brass	**Reference Document**	CSA or ASME Certification
Spring	Stainless Steel	**Size Range**	<3”
Elastomers	-	**Body/Valve Ends**	NPT, FNPT (Note 3)
		Pressure Rating (psi)	150 PSI (Note 2)
		Temperature Rating (deg C)	-
		Testing	-
		Operator	Adjustment nut/screw
		Actuator	-

NOTES
1. Valve shall be NSF 61certified for potable water applications– Lead free.
2. Valve shall be adjustable with range suitable for the installation.
3. A strainer shall be provided ahead of all PCVs and PRVs

ACCEPTABLE PRODUCTS		
Watts	Mueller	Apollo 36ELF (1/2” – 1”)
Apollo 36H (1 ¼” – 3”)		

Pressure Regulating Valve

TYPE OF VALVE		**SYMBOL**	
Pressure Regulating Valve (Backpressure and Pressure Relief)		PRV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Water, Chemical – Sodium Hypochlorite <15%, (or Chlorine Gas Solution)
Body	PVC Type 1 or Polypropylene	**Reference Document**	-
Seat Ring	-	**Size Range**	≤3”
Elastomers	PTFE seats or Viton	**Body/Valve Ends**	Union with Socket Weld (Note 1)
		Pressure Rating (psi)	150 PSI
		Temperature Rating (deg C)	140 F PVC; PP 195 F
		Testing	-
		Operator	Adjustment nut/screw
		Actuator	-
NOTES			
1. Valve shall have threaded double-union body that can be removed from the line without disengaging the end connections.			
ACCEPTABLE PRODUCTS			
Grifco G Series	Plastomatic	Asahi/America, Inc	
Hayward Flow Control			

Pressure Regulating Valve

TYPE OF VALVE		**SYMBOL**	
Pressure Regulating Valve (Backpressure and Pressure Relief)		PRV-3	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Ferric Chloride, Sodium Bisulfite, Aluminum Sulfate, Sodium Hydroxide (Note 2), or Citric Acid
Body	PVC Type 1 or Polypropylene	**Reference Document**	-
Seat Ring	-	**Size Range**	<2”
Elastomers	PTFE Seats, EPDM or Viton (Note 2)	**Body/Valve Ends**	Union with Socket Weld (Note 1)
		Pressure Rating (psi)	150 PSI
		Temperature Rating (deg C)	140 F PVC; PP 195 F
		Testing	-
		Operator	Screw Adjust
		Actuator	-
NOTES			
1. Valve shall have threaded double-union body that can be removed from the line without disengaging the end connections.			
2. When used with sodium hydroxide, valve elastomers shall be PTFE only.			
ACCEPTABLE PRODUCTS			
Griffco G Series	Plastomatic	Hayward Flow Control	

Pressure Regulating Valve

TYPE OF VALVE		**SYMBOL**	
Pressure Regulating Valve (Backpressure and Pressure Relief)		PRV-4	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Chemical – Sodium Hydroxide (Caustic Soda)
Body	316 SS	**Reference Document**	-
Seat Ring	-	**Size Range**	<2”
Elastomers	PTFE Diaphragm	**Body/Valve Ends**	Union with Socket Weld (Note 1,2)
		Pressure Rating (psi)	150 PSI
		Temperature Rating (deg C)	300 F
		Testing	-
		Operator	Screw Adjust
		Actuator	-

NOTES
1. Valve shall have threaded double-union body that can be removed from the line without disengaging the end connections.
2. No threaded ends, socket weld or Flanged only.

ACCEPTABLE PRODUCTS		
Asahi/America, Inc.	Griffco G Series	Plastomatic

Pinch Valve

TYPE OF VALVE		**SYMBOL**	
Pinch Valve		PIV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS**	**Type of Service**	Sewage, Water, Sludge, Mixed Liquor
Body	Ductile Cast Iron. The valve face-to-face dimensions shall be as given in ASME/ANSI B16.10. Open Body designs shall not be permitted.	**Reference Document**	-
Stem/ Pinch Mechanism	The pinch mechanism shall be double acting, centerline closure. The mechanism shall be supported in the valve body. (Note 3).	**Size Range**	4" to 24"
Sleeve	Buna-N inner tube in contact with the process, a high strength nylon, polyester or Kevlar fabric as recommended by the manufacturer for the conditions. The layers shall be vulcanized together to for a tough, maintenance free sleeve. (Note 1)	**Body/Valve Ends**	ANSI B16.1, Class 125/ANSI B16.5, Class 150 flanges
Sleeve Trim	Flange bolts shall not penetrate the sleeve as to retain its position allowing for in-line tube change, without removing the entire valve from the pipeline. No recalibration should be required in sleeve replacement. All internal valve metal parts are to be completely isolated from the process fluid by the sleeve.	**Pressure Rating (psi)**	Throttling Service 150 PSI
		Temperature Rating (deg C)	-
		Testing	-
		Operator	-
		Actuator	Motorized with manual override. Electric actuators as shown on the plans and as specified in Division 16. (Note 2)
NOTES			
1. The port areas shall be 100% of the full pipe area at the valve ends and have inlet and outlet cones as identified on the drawings.			

2. For below-grade applications (inside vaults), a torque tube shall be fitted to the body of the valve via a mounting plate. The tube shall extend from the valve to 36" above grade level, providing protection for the operating stem and supporting the motorized actuator. Coordinate actuator mounting stem/plate with actuator mfr.		
3. The pinch mechanism shall be adjustable for stroke without removing the valve from the line.		
4. The pinch valve and actuator assembly shall be integrated, adjusted, tested and have start-up services performed by an authorized manufactures representative.		
ACCEPTABLE PRODUCTS		
Red Valve Series 5200E or Series 5200ED	RF Valve – Enclosed Body	

Plug Valve

TYPE OF VALVE	**SYMBOL**
Eccentric Plug Valve	PV-1

VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Sewage, Sludge, Scum
Body	ASTM A126 Class B cast iron	**Reference Document**	ANSI/AWWA C517 Eccentric Plug Valves
Type of Plug	Eccentric, non-lubricated	**Size Range**	3" TO 36"
Plug	Standard and 3-way plug valves shall have resilient plug facings shall be of neoprene suitable for use with sewage, sludge or scum. (Note 4)	**Body/Valve Ends**	ANSI B16.1 125/ B16.5 150# FL or MJ or screwed as shown on drawings (Note 3)
Packing/Sealing	1)4" and larger valves shall be re-packable and adjustable packing without removing the bonnet 2) Lip Seal	**Pressure Rating (psi)**	150 PSI
Trim	SS	**Temperature Rating (deg C)**	300 F
Shaft	SS	**Testing**	-
Seats	Raised seats. Seats in 3" and larger valves shall have a welded-in overlay of high nickel content on all surfaces contacting the plug face. (Note 4, 5)	**Operator**	Geared (Note 2)
Bearings	Body: 316L SS Sealed, permanently lubricated in upper and lower stem journals; Thrust: PTFE	**Actuator**	Automated pneumatic or electric motor actuator as indicated on the plans and specifications.
Bonnet	Bolted, ASTM A126 Class B cast iron		

NOTES

1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free.
2. Valves shall have gear actuators and tee wrenches, extension stems, floor stands, chain-wheels, etc., as required or indicated on the Plans. Quarter turn lever actuators required if specifically noted on the Plans. All gearing shall be enclosed in a semi-steel housing and be suitable for running in a lubricant with seals provided on all shafts to prevent entry of dirt and water into the actuator allowing for submerged or buried service. The actuator shaft and the quadrant shall be supported on permanently lubricated bronze bearings. Actuators, if required, shall clearly indicate valve position, and an adjustable stop shall be provided to set closing torque.
3. Flanges of valves through 12" shall have face-to-face dimensions of standard gate valves.
4. Port areas of valves shall be a minimum of 80% of full pipe area.
5. ***Valves installed in sludge lines shall be installed with the seat on the upstream side and shall be designed for bi-directional service.***

ACCEPTABLE PRODUCTS

Dezurik	Pratt	Milliken	Val-Matic

- All exposed nuts, bolts, springs and washers shall be zinc-plated.
- Valves and gear actuators for buried or submerged service shall have seals on all shafts and gaskets on the valve and actuator covers to prevent the entry of water. Actuator mounting brackets for buried or submerged service shall be totally enclosed and shall have gasket seals. All exposed nuts, bolts, springs and washers shall be stainless steel.

Shear Gate Valve

TYPE OF VALVE		**SYMBOL**	
Shear Gate Valve		SGV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1, 2)	**Type of Service**	Liquid (Water or Sewage, Mixed Liquor)
Body	Cast Iron, ASTM 126B	**Reference Document**	-
Mounts	Bronze	**Size Range**	4" to 12"
Seat Wedges/ Seal Faces	Cast Iron, ASTM 126B, replaceable. Mounted with SS hardware.	**Body/Valve Ends**	ANSI B16.1, Class 125/ANSI B16.5, Class 150 flanged end
Disc	Cast Iron, ASTM 126B	**Pressure Rating (psi)**	30 ft WC
Seat rings, disc ring, hinge bolt and hinge nut	Bronze, B62.	**Temperature Rating (deg C)**	-
Lift rods	¾" diameter carbon steel. Shall be used to manually raise and lower the Shear Gate disc from a position above the gate.	**Testing**	-
		Operator	Handle, with extensions shall be furnished to elevations shown on Plans.
		Actuator	-
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified– Lead free.			
2. Full opening, circular port.			
ACCEPTABLE PRODUCTS			
Clow	M&H		

Solenoid Valve

TYPE OF VALVE		**SYMBOL**	
Solenoid Valve		SV-1	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water, Filtered Process Water (free chlorine <10 ppm)
Body	PVC	**Reference Document**	
Seals	FKM	**Size Range**	½" to 2"
		Body/Valve Ends	NPT/FNPT
		Pressure Rating (psi)	150
		Temperature Rating (deg C)	
		Testing	
		Operator	
		Actuator	Solenoid magnet (Note 2)
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free.			
2. Valve configuration data (normally (fail) closed, or normally (fail) open) shall be submitted to Engineer prior to ordering.			
ACCEPTABLE PRODUCTS			
Plast-O-Matic Z-Cool series (voltage per electrical requirements).			

Solenoid Valve

TYPE OF VALVE		**SYMBOL**	
Solenoid Valve		SV-2	
VALVE MATERIALS		**VALVE DESCRIPTION**	
ITEM	**MATERIALS** (Note 1)	**Type of Service**	Water, Filtered Process Water (free chlorine <10 ppm); Class I, Division I hazardous area
Body	Stainless Steel	**Reference Document**	
Diaphragm	FKM	**Size Range**	½" to 2"
O-rings	FKM	**Body/Valve Ends**	NPT/FNPT
		Pressure Rating (psi)	150
		Temperature Rating (deg C)	
		Testing	
		Operator	
		Actuator	Solenoid magnet (Note 2)
NOTES			
1. For Potable Water Applications, Valve shall be NSF 61 certified – Lead free.			
2. Valve configuration data (normally (fail) closed, or normally (fail) open) shall be submitted to Engineer prior to ordering.			
ACCEPTABLE PRODUCTS			
Burkert Type 5282 (voltage per electrical requirements).			

END OF SECTION

SECTION 43 30 12
VALVE AND GATE ACTUATORS

PART 1 -- GENERAL

1.01 THE SUMMARY

A. Provide valve and gate actuators and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section apply to valves and gates except where otherwise indicated in the Contract Documents.

C. Unit Responsibility

1. Make the valve or gate manufacturer responsible for the coordination of design, assembly, testing, and installation of actuators on the valves and gates; however, the Contractor shall be responsible to the Owner for compliance of the valves, gates, and actuators with the Contract Documents.

D. Where two or more valve or gate actuators of the same type or size are required, the actuators shall be produced by the same manufacturer.

E. The requirements of Section 26 05 15 – Industrial Control Panels apply to the Work of this Section.

1.02 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures and Section 43 30 00 – Hydraulic Process Valves.

B. Submit Shop Drawing information for actuators with the valve and gate submittals as a complete package.

C. Submit calculations showing dynamic seating and unseating torques versus the output torque of the actuator.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, provide shut-off and throttling valves and externally actuated valves and gates with manual or power actuators.

B. Provide actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, hand wheels, levers, chains, and extensions, as applicable.

C. Provide actuators with torque ratings equal to or greater than required for valve seating and dynamic torques, whichever is greater, and capable of holding the valve in any

intermediate position between fully-open and fully-closed without creeping or fluttering.

D. Actuator torque ratings for butterfly valves shall be determined in accordance with American Water Works Association (AWWA) C504 - Rubber-Seated Butterfly Valves.

E. Identify wires of motor-driven actuators by unique numbers.

F. Manufacturers

1. Where indicated, certain valves and gates may be provided with actuators manufactured by the valve or gate manufacturer.

2. Where actuators are furnished by different manufacturers, coordinate the selection to result in the fewest number of manufacturers possible.

G. Materials

1. Provide actuators of current models, of the best commercial quality materials, and liberally sized for the required torque.

2. Provide materials suitable for the environment in which the valve or gate is to be installed.

H. Actuator Mounting and Position Indicators

1. Securely mount actuators by means of brackets or hardware specially designed and sized for this purpose and of ample strength.

2. Cast the word "OPEN" on each valve or actuator, with an arrow indicating the direction to open in the counterclockwise direction.

3. Equip gear and power actuators with position indicators.

4. Where possible, locate manual actuators between 48 and 60 inches above the floor or the permanent working platform.

I. Standards

1. Unless otherwise indicated and where applicable, provide actuators in accordance with AWWA C 542 - Electric Motor Actuators for Valves and Slide Gates.

J. Functionality

1. Coordinate electric, pneumatic, and hydraulic actuators with the power requirements of Division 26 – Electrical, and instrumentation equipment as indicated in Section 40 91 00 – Process Control and Instrumentation Systems.

K. Provide fasteners in accordance with the requirements of Section 05 50 00 – Metal Fabrications.

L. Provide coatings in accordance with the requirements of Section 09 90 00 – High Performance Coatings.

2.02 MANUAL ACTUATORS

A. General

1. Unless otherwise indicated, provide valves and gates with manual actuators.
2. Provide valves in sizes up to and including four inches with direct-acting lever or hand wheel actuators of the manufacturer's best standard design.
3. Provide valves and gates larger than 4-inch with gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the hand wheel.
4. Provide buried and submerged gear-assisted valves, gates, gear-assisted valves for pressures higher than 250 pounds per square inch gauge (psig), valves 30-inches in diameter and larger, and where indicated, with worm gear actuators, hermetically-sealed water-tight and grease-packed.
5. Valves 6-inch to 24-inch diameter may be provided with traveling-nut actuators, worm gear actuators, spur or bevel gear actuators, as appropriate for each valve.

B. Buried Valves

1. Unless otherwise indicated, provide buried valves with extension stems to grade, with square nuts or floor stands, position indicators, and cast-iron or steel pipe extensions with valve boxes, covers, and operating keys.
2. Where indicated, provide buried valves in cast-iron, concrete, or similar valve boxes with covers of ample size in order to allow operation of the valve actuators.
3. Permanently label the valve box covers as required by the local Utility Company or the Engineer.
4. Provide wrench-nuts in compliance with AWWA C 500 - Metal-Seated Gate Valves for Water Supply Service.

C. Chain Actuator

1. Provide manually-activated valves with the stem located more than seven feet above the floor or operating level with chain drives consisting of sprocket-rim chain wheels, chain guides, and operating chains supplied by the valve manufacturer.
2. Construct the wheel and guide from ductile iron, cast iron, or steel.
3. Chains
    a. Fabricate the chain from hot-dip galvanized steel or stainless steel, and extend to five feet six inches above the operating floor level.
    b. Provide an extra strong valve stem on chain-actuated valves in order to allow for the extra weight and chain pull.
    c. Provide hooks for chain storage where chains interfere with pedestrian traffic.

D. Floor Boxes

1. Provide hot-dipped galvanized cast iron or steel floor boxes and covers to fit the slab thickness, for operating nuts in or below concrete slabs.

2. For operating nuts in the concrete slab, provide a bronze-bushed cover.

E. Tee Wrenches

1. Furnish buried valves with floor boxes with 2 operating keys or one key per 10 valves, whichever is greater.

2. Size the tee wrenches such that the tee handle will be 2 to 4 feet above ground, and to fit the operating nuts.

F. Manual Worm Gear Actuator

1. Provide an actuator consisting of a single- or double-reduction gear unit contained in a weatherproof cast iron or steel body with cover, and a minimum 12-inch diameter handwheel.

2. Provide the actuator to be capable of a 90-degree rotation, and equip the actuator with travel stops capable of limiting the valve opening and closing.

3. Provide the actuator with spur or helical gears and worm gearing.

4. Provide a self-locking gear ratio in order to prevent "back-driving."

5. Construct the spur or helical gears of hardened alloy steel, and the worm gear of alloy bronze.

6. Construct the worm gear shaft and the hand wheel shaft from 17-4 PH or similar stainless steel.

7. Accurately cut gearing with hobbing machines.

8. Use ball or roller bearings throughout.

9. Provide the output shaft end with a spline in order to allow adjustable alignment.

10. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator.

11. Design gearing for a 100 percent overload.

12. The entire gear assembly shall be sealed weatherproof.

G. Design and rate buried gear actuators for buried service, provide with a stainless steel input shaft, and double-seal on shaft and top cap.

H. Traveling-Nut Actuator

1. Provide the actuator with a traveling-nut and screw (Scotch yoke), contained in a weatherproof cast iron or steel housing with a spur gear and a minimum 12-inch diameter hand wheel.

2. The screw shall run in two end bearings, and provide a self-locking actuator in order to maintain the valve position under any flow condition.

3. Construct the screw and gear from hardened alloy steel or stainless steel, and the construct the nut and bushings from alloy bronze.

4. The bearings and gear shall be grease-lubricated by means of nipples.

5. Design gearing for a 100 percent overload.

2.03 ELECTRIC MOTOR ACTUATORS

A. General

1. Equipment Requirements

a. Where electric motor actuators are indicated, attach an electric motor-actuated valve control unit to the actuating mechanism housing by means of a flanged motor adapter piece.

2. Gearing

a. Provide the motor actuator with the motor, reduction gearing, reversing starter, torque switches, and limit switches in a weather-proof National Electrical Manufacturers Association (NEMA) 4X assembly.

b. Provide a single- or double-reduction unit, consisting of spur or helical gears and worm gearing.

c. Construct the spur or helical gears of hardened alloy steel, and the worm gear of alloy bronze.

d. Accurately cut gearing with hobbing machines.

e. Power gearing shall be grease- or oil-lubricated in a sealed housing.

f. Use ball or roller bearings throughout.

g. Actuator output speed changes shall be mechanically possible by simply removing the motor and changing the exposed or helical gearset ratio without further disassembly of the actuator.

3. Starting Device

a. Except for modulating valves, design the unit such that a hammer blow is imparted to the stem nut when opening a closed valve or closing an open valve.

b. The device shall allow free movement at the stem nut before imparting the hammer blow.

c. The actuator motor shall attain full speed before the stem load is encountered.

4. Switches

a. Electronic-Type Switches

i. Limit switches or valve position shall be sensed by a 15-bit, optical, absolute position encoder.

ii. The open and closed positions shall be stored in a permanent, non-volatile memory.

iii. The encoder shall measure valve position continuously, including both motor and hand wheel operation, with or without use of battery.

iv. Provide an electronic torque sensor.

v. Provide an adjustable torque limit, from 40 to 100 percent of rating in one-percent increments.

vi. The motor shall be de-energized if the torque limit is exceeded.

vii. Provide a boost function in order to prevent torque-trip during initial valve unseating, and a “jammed valve” protection feature with automatic retry sequence in order to de-energize the motor if no movement occurs.

viii. Provide valve actuators with electronic type switches as manufactured by **Limitorque, Rotork** or **Auma Actuators, Inc**.

b. The actuator shall be wired in accordance with the schematic diagram.

c. Connect wiring for external connections to marked terminals.

d. Provide one 1-inch and one 1-1/4-inch conduit connection in the enclosing case.

e. Mount a calibration tag near each switch, correlating the dial setting to the unit output torque.

f. Switches shall not be subject to breakage or slippages due to over-travel.

g. Do not use traveling-nuts, cams, or microswitch tripping mechanisms.

h. Provide limit switches of the heavy-duty, open contact type, with rotary wiping action.

5. Handwheel Operation

a. Provide a permanently attached handwheel for emergency manual operation.

b. The handwheel shall not rotate during electrical operation.

c. The maximum torque required on the handwheel under the most adverse conditions shall not exceed 60 pound-foot, and the maximum force required on the rim of the handwheel shall not exceed 60 pounds.

d. Cast or permanently affix an arrow and either the word "OPEN" or "CLOSE" on the handwheel in order to indicate the appropriate direction to turn the handwheel.

e. Provide a clutch lever to put the actuator into handwheel operation.

f. Provide chain activator handwheels for valves with electric motor actuators having stems more than seven feet above the floor.

g. Provide the clutch lever with a cable secured to the chain in order to allow disengagement for manual operation.

6. Motor

a. Provide a motor of the totally enclosed, non-ventilated, high-starting torque, low-starting current type, for full-voltage starting.

b. The motor shall be suitable for operation on 480-volt, 3-phase, 60-Hz current, with Class F insulation and a motor frame with dimensions in accordance with the latest revised NEMA MG Standards.

c. The observed temperature rise by thermometer shall not exceed 55°C above an ambient temperature of 40°C, when operating continuously for 15 minutes under full-rated load.

d. With a line voltage ranging between 10 percent above to 10 percent below the rated voltage, the motor shall develop full-rated torque continuously for 15 minutes without causing the thermal contact protective devices imbedded in the motor windings to trip or the starter overloads to drop out.

e. Provide bearings of the ball type, and provide thrust bearings where necessary.

f. Provide the bearings with suitable seals in order to confine the lubricant and to prevent the entrance of dirt and dust.

g. Provide watertight motor conduit connections.

h. Motor construction shall incorporate the use of stator and rotor as independent components from the valve operation such that the failure of either item shall not require actuator disassembly or gearing replacement.

i. Provide two Class B thermal contacts or solid-state thermistors embedded within the motor windings in order to protect against over-temperature damage.

j. Provide the motor with a space heater suitable for operation on a 120-volt, single-phase, 60-Hz circuit, unless the entire actuator is of a hermetically sealed, non-breathing design with a separately sealed terminal compartment which prevents moisture intrusion.

k. Provide each electric motor actuator with a local disconnect switch or circuit breaker in order to isolate power from the motor and controller during maintenance activities.

7. Controls

a. Furnished actuator controls shall be as per the control functions detailed in the piping and instrumentation diagram (P&ID) drawings and Division 40 specifications

b. Where hardwired controls are indicated, the furnished actuator control module shall support signaling as follows:

c. Discrete Position Open Status

d. Discrete Position Closed Status

e. Discrete control status (Local/Remote).

f. Discrete Open / Close Command (single output)

g. Discrete high-high torque alarm

h. 4-20 mA Position Feedback (for modulating valves)

i. 4-20 mA Position Control Signal (for modulating valves)

j. Refer to the P&ID drawings for any additional hardwired signaling requirements for specific valves and gates

k. Status lights shall be red for "OPEN" and green for "CLOSED."

8. Open/Close Operating Speed

a. Unless otherwise indicated, electric actuators shall provide a full-close-to-full- open or full-open-to-full-close operating time range from 30 to 55 seconds.

b. Open/close speed of motor/power-actuated valves/gates shall be as indicated in the control valve/gate actuator schedule.

9. Valve and gate tag numbers, locations, area classifications, service, size, operating head, communication type, and motor type shall be as indicated in the valve/gate actuator schedule.

10. Elevated Valves

a. For valves with electric motor actuators where the valve centerline is located at a height greater than 6 feet above the floor, provide a remote actuator control station at a location no higher than four feet above the floor.

b. Provide conduit and wiring between the actuator controls and the valve actuator for these applications.

c. Wall-mount the actuator controls beneath the valve at a location approved by the Engineer.

B. Electric Motor Actuators (AC Reversing Control Type)

1. General

a. Where indicated, electric motor actuators shall be the AC reversing type complete with local control station with OPEN/CLOSE and LOCAL/OFF/REMOTE selector switches.

2. Actuator Appurtenances

a. Provide the actuator for each valve with: OPEN and CLOSE status lights; OPEN, CLOSE, and LOCKOUT/STOP push buttons; and, other indicated devices.

3. Starter

a. Provide a suitably sized amperage-rated reversing starter with its coils rated for operation on 480-volt, 3-phase, 60-Hz current.

b. Provide a control power transformer in order to provide a 120-volt source, unless otherwise indicated.

c. Equip the starter with 3 overload relays of the automatic reset type, and wire the control circuit as indicated.

d. The integral weatherproof compartment shall contain a suitably sized 120-volt AC, single-phase, 60-Hz space heater in order to prevent moisture condensation on electrical components.

e. Provide a local power disconnect switch and a close-coupled, padlockable switch with each actuator.

4. Local Control Station

a. Provide each actuator with a local control station along with the valve actuator assembly as indicated on the P&IDs.

b. The station shall include OPEN, CLOSE, and STOP push buttons, and a LOCAL/OFF/REMOTE selector switch.

c. The local control station and local power disconnect may be provided as an integral part of the actuator, or as otherwise indicated or required in order to permit operation by a person at floor elevation and within sight of the valve actuator.

5. Electric Motor Actuators (AC Reversing Control Type) Manufacturer, or Equal

a. EIM

b. Auma Actuators, Inc.

c. Limitorque Corp

d. Rotork

C. Electric Motor Actuators (AC Modulating Control Type)

1. General

a. Where indicated, modulating electric motor actuators shall be of the AC-modulating type, provided complete with a local control station with power disconnect switch or circuit breaker, LOCAL/OFF/REMOTE switch, non-latching OPEN/CLOSE pushbuttons, and OPEN/CLOSE status lights

2. Actuator Appurtenances

a. Provide the actuator for each valve with: a padlockable disconnect switch; OPEN and CLOSED status lights; OPEN, CLOSE, and LOCKOUT/STOP pushbuttons; a LOCAL/REMOTE selector switch; and, other indicated devices.

3. Control Module

a. Provide a control module of the electronic solid-state AC type, with control outputs for positioning the valve via four to 20 mA input signals.

4. Starter

a. The actuator shall control a solid-state reversing starter designed for minimum susceptibility to power line surges and spikes.

b. The solid-state starter and control module shall be rated for continuous modulating applications.

c. The power supply shall be 480-volt, 3-phase, 60-Hz.

d. Provide a disconnect switch with each actuator.

5. Construction

a. The control unit shall be microprocessor-based and shall contain an analog/digital converter, separate input-output switches, non-volatile random access memory for storage of calibration parameters, and push-button calibration elements for field setup.

b. Potentiometer adjustments shall contain a PID control function internally.

c. The controller shall contain as a standard feature a loss-of-command signal protection selectable to lock in last or lock in pre-set valve position and a valve position output signal in 4 to 20 mA.

d. As an alternative to the construction requirement, provide a motor capable of modulating at a rate of 600 starts per hour at the 50 percent to 85 percent travel range of the valve.

e. The system shall allow the control of the open, close, or percent open function when the LOCAL/OFF/REMOTE switch is in the REMOTE position.

f. Provide each actuator with a frequency shut-down system, which when pre-programmed shall function as directed upon receipt of an ESD signal.

6. Electric Motor Actuators (AC Modulating Control Type) Manufacturer, or Equal

a. **EIM**

b. **Limitorque**

c. **Rotork**

d. **Auma Actuators, Inc.**

D. Electric Motor Actuators (DC Modulating Control Type)

1. Equipment Requirements

a. Where indicated, provide electric motor actuators of the DC modulating control type, and attach to the actuating mechanism housing.

2. Actuator Assembly

a. The assembly shall include a DC motor, reduction gearing, a control unit, limit-switches, and required accessories, within one enclosure.

3. Control Unit

a. Provide an electric motor-operated control unit suited for an input power supply of 90 to 140 volts, 60 Hz AC, and to operate satisfactorily when input power is within those limits.

b. Power will be supplied at 120 volts, single-phase, 60 Hz AC.

c. Provide a control unit suited to receive an input set-point signal from an external source of 4 to 20 ma DC with properly selected calibrating resistor.

4. Control Panel

a. Provide each actuator with a separate local control panel for attachment to the valve actuator assembly.

b. Provide the panel with an OPEN/CLOSE/AUTO/HOLD selector switch and suitable for indoor or outdoor installation, as required.

5. Electric Motor Actuators (DC Modulating Control Type) Manufacturer, or Equal

a. **EIM, Futronic-III**

b. **Limitorque Corp., Modutronic-10**

E. 120 V Quarter-Turn and Multi-Turn Electric Valve Operators (6-Inches and Smaller)

1. Provide 120-volt, single-phase, motor-operated valve operators suitable for use with quarter-turn ball valves, multi-turn diaphragm valves, and multi-turn globe valves.

2. Provide operators with the following characteristics and features:

a. reversing capacitor-start motor rated for operation on 120 VAC, 60 Hz, single-phase;

b. output torque as required for valve application and pressure differential;

c. integral motor overload protection, with auto-reset;

d. permanently-lubricated gear train;

e. OPEN/CLOSE Control

i. For OPEN/CLOSE control, provide 4 single-pole, double-throw cam-actuated limit switches (2 OPEN, 2 CLOSED);

ii. Use one set of limit switches for both motor control and local indication;

iii. Make the other set available for connection to remote monitoring;

iv. Provide adjustable limit switch contacts rated for not less than 5 amps at 120 VAC;

f. Local Control Station: OPEN/CLOSE

i. corrosion-resistant, NEMA 4X, for mounting near valve actuator;

ii. Provide 2-position selector switch for LOCAL/REMOTE selection and 2 pushbuttons, OPEN and CLOSE;

iii. Provide OPEN and CLOSE indicating lights operating at 120 VAC for connection to valve control limit switches;

g. Modulating Control

i. For modulating control, provide an electronic positioner and feedback potentiometer;

ii. The positioner shall use a 4 to 20 ma signal to adjust the valve opening;

iii. Feedback potentiometer shall be 0 to 1000 ohms;

h. Local Control Station Modulating

i. corrosion resistant, NEMA 4X, for mounting near valve actuator;

ii. Provide 2-position selector switch for LOCAL/REMOTE selection, one OPEN and one CLOSE push button, a resistance-to-current converter with 4 to 20 mA output, and a zero to 100 percent electronic valve position indicator; and,

i. Disconnect Switch

i. Provide a local power disconnect switch, NEMA 4X, for disconnecting the 120 VAC power to the valve; and,

ii. Install the disconnect in the field within sight of the valve actuator, in accordance with the requirements of National Fire Protection Agency (NFPA) 70.

3. Refer to the Drawings for the control diagram wiring interface.

4. Two-wire control systems are not required for this actuator.

5. 120 V Quarter-Turn and Multi-Turn Electric Valve Operators (6-Inches and Smaller) Manufacturer, or Equal

a. **RCS**

b. **Asahi/America, Quarter Master**

2.04 PNEUMATIC ACTUATORS

A. General

1. Controls

a. Provide pneumatic cylinder actuators with every necessary pneumatic or electro-pneumatic control for the intended actuation of the valve or gate.

b. Manufacturer, or Equal

i. **G.H. Bettis/Shafer**

ii. **Fisher Controls**

iii. **Miller Fluid Power**

iv. **Neles-Jamesbury, Inc.**

v. **Rexroth Corporation**

2. Filters, Regulators, and Lubricators

a. Where required by the service and type of actuator, provide filters, regulators, and oil-lubricators in the air supply to the actuator, according to the manufacturer's instructions.

3. Air Supply

a. Size pneumatic actuators for the available air pressure as indicated, and provided with isolating valves, adjustable filter-regulators, pressure gauges, and condensate drains.

b. The filter elements shall be replaceable 40-micron units.

c. Manufacturer, or Equal

vi. **Fisher Controls**

vii. **Miller Fluid Power**

B. Diaphragm Actuators

1. Construction

a. Provide an actuator consisting of: a ductile-iron, aluminum, or carbon steel diaphragm housing, and stainless steel or carbon steel stem; a ductile-iron or cast-iron yoke and spring barrel with carbon steel spring; and, Nitrile-covered fabric diaphragm of sufficient strength for the maximum expected torque or force.

2. Manual Override

a. Provide each actuator with a manual handwheel override, top-mounted for linear actuation, and worm gear mounted with declutchable handwheel for rotary actuation.

b. The worm gear construction shall be as indicated for manual actuators.

3. Manufacturer, or Equal

a. **Fisher Corporation**

b. **ITT Engineered Valves**

c. **Neles-Jamesbury, Inc**

PART 3 -- EXECUTION

3.01 SERVICES OF MANUFACTURER

A. Field Adjustments

1. The adjustment of actuator controls and limit switches in the field for the required function shall be performed by field representatives of the manufacturers of valves or gates with pneumatic, hydraulic, or electric actuators.

3.02 INSTALLATION

A. Install valve and gate actuators and accessories in accordance with the requirements of Section 43 30 00 – Hydraulic Process Valves.

B. Locate the actuators to be readily accessible for operation and maintenance without obstructing walkways.

C. Do not mount actuators where shock or vibrations will impair their operation, and do not attach the support systems to handrails, process piping, or mechanical equipment.

END OF SECTION

SECTION 43 30 62
STAINLESS STEEL SLIDE GATES AND WEIR GATES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section covers stainless steel slide gates, stop gates, weir gates and operators as shown on the plans, listed in the gate schedules and as specified herein.

B. The equipment provided under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer.

C. Gates and operators shall be supplied with all the necessary parts and accessories indicated on the drawings, specified, or otherwise required for a complete, properly operating installation, and shall be the latest standard product of a manufacturer regularly engaged in the production of fabricated gates.

D. Refer to the gate schedule on Sheet 00-G-016 in the Contract Drawings.

1.2 REFERENCES

A. ASTM International ASTM A276 – Stainless steel bars and shapes

B. American Water Works Association (AWWA) C561 - latest edition

C. ASTM D4020 – Standard Specification for Ultra-High-Molecular-Weight Polyethylene Molding and Extrusion Materials

1.3 DEFINITIONS

A. A weir gate is a downward opening slide gate with flow over the top.

1.4 DESIGN REQUIREMENTS

A. Gate configuration, components and accessories shall be of the size and type shown on the drawings and gate schedule and specified herein.

B. Gates shall be designed for continuous immersion in raw wastewater.

C. Except as modified or supplemented herein, all gates and operators shall conform to the applicable requirements of AWWA-C561 standards.

D. Leakage: Gates shall be substantially watertight under the design head conditions. Under the design seating head, the leakage shall not exceed 0.05 US gallons per minute per foot of seating perimeter. Under the design unseating head, leakage shall not exceed 0.05 US gallons per minute per foot of perimeter.

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 00 and Divisions 43, 46 with the following additional information:

1. Fabrication drawings with full dimensions, construction and installation details, and materials used on all parts of the gate, operator, lift, and appurtenances. General arrangement drawings and cut sheets are not considered acceptable drawings.

2. Plan, cross section, and details showing proposed mounting for each size and typical application of gate.

3. Applicable operation and maintenance information as specified in Section 01 73 00.

4. Complete engineering design calculations in compliance with AWWA standards, latest edition.

1.6 WARRANTY

A. Equipment supplied under this section shall be warranted to be free from defects in workmanship, design and materials for a period of one (1) year from the date of Substantial Completion. If any part of the equipment should prove to be defective during the warranty period, the Manufacturer shall replace the part at no expense to the Owner.

1.7 QUALITY ASSURANCE

A. The gate manufacturer shall have a minimum of five (5) years of experience producing equipment substantially similar to that required and shall be able to submit documentation of at least fifteen (15) independent installations using the same size or larger equipment as detailed below. Each installation must have been in satisfactory operation for at least five (5) years.

B. The contract documents represent the minimum acceptable standards for the equipment. All equipment shall conform fully in every respect to the requirements of the respective parts and sections of the drawings and specifications. The entire unit shall be Manufacturer's standard product, but shall be modified, redesigned, furnished with special features or accessories, made of materials or provided with finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of the specification.

C. Fabrication shall be done in compliance with all applicable ASTM standards or equivalent international standards.

D. The manufacturer's shop welds, welding procedures, and welders shall be qualified and certified in accordance with the requirement of the latest edition of American Welding Society (AWS) Sections D1.1, 1.2, and 1.6.

E. The Contractor or Subcontractor responsible for the installation of the gates shall have five or more years of experience in the installation of similar type gates.

F. All fully assembled gates shall be shop inspected, tested for operation and leakage, and adjusted before shipping. There shall be no assembling or adjusting on the job sites other than for the lifting mechanism.

1.8 DESIGN REQUIREMENTS

A. Gate configuration, components, and accessories shall be of the size and type shown on the Drawings and gate schedule and specified herein.

B. Gate, frame, and yoke design shall be such that the flexural stress does not exceed 10,000 pounds per square inch (psi) or that the minimum safety factor is 5-to-1 based on the ultimate strength of the material used.

C. Gate shall be designed for continuous immersion in raw wastewater. Fluid temperature is expected to range from 35^{o}F to 90^{o}F.

D. Except as modified or supplemented herein, gate and operators shall conform to the applicable requirements of AWWA-C561 standards.

E. Leakage: Gate shall be substantially watertight under the design head conditions. Under the design seating and unseating heads, the leakage shall not exceed 0.05 US gallons per minute per foot of seating perimeter.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. In order to ensure uniform quality, ease of maintenance and minimal parts storage, all gates supplied under this section shall be supplied by a single manufacturer unless noted otherwise.

1. Whipps
2. Golden Harvest, Inc.
3. RW Gate Company
4. Waterman
5. Rodney Hunt
6. Approved Equal

2.2 MATERIALS AND CONSTRUCTION

A. General Design

1. Gates shall be either self-contained or non-self-contained of the rising stem or non-rising configuration as indicated on the gate schedule.

2. All parts of the gate shall have a minimum thickness of ¼-inch.

B. Frame

1. Gate frame shall conform to the safety factors specified in AWWA C561.
2. Gate frame shall be designed for embedding, in-channel, or face mounting as showing on the drawings or gate schedule.
3. The gate frame shall be stainless steel and designed for maximum rigidity.
4. The frame configuration shall be of the flush-bottom type and shall allow the replacement of the top and side seals without removing the gate frame from the wall.
5. Lifting Lugs shall be provided on frame styles.
6. Frame shall be single piece construction; bolted frames are not acceptable. Wraparound gussets shall be provided where frame stresses require additional reinforcement.

C. Slide

1. Gate slide shall conform to the safety factors specified in AWWA C561 but shall, in no case, be less than ¼-inch thick. The slide shall consist of a stainless-steel plate that is reinforced with horizontal and vertical stiffeners. The stem connector clips or stem block pocket shall be welded to the slide. Horizontal reinforcement members welded to side vertical members. The slide shall consist of stainless-steel plate reinforced to limit its deflection. The limits of deflection shall be:
    a. Slide Gate: L/720 of the gate's span under the design head or 1/16 inch, whichever is less.
    b. Weir Gate: L/720 of the gate's span under the design head or 1/16 inch, whichever is less.

D. Guides and Seals

1. The guides shall be provided with ultra-high molecular weight polyethylene seats on both sides of the slide and shall be of such length as to retain and support at least two thirds (2/3) of the vertical height of the slide in the fully open position.
2. Guide frame shall not weigh less than 13 pounds per foot.
3. Slide gate shall incorporate a flush-bottom seal that is attached to the bottom frame invert member. The seal shall be of the materials listed in “Materials of Construction” and shall meet the material test requirements specified in AWWA C561.
    a. The design of the seal shall be such as to provide resistance against leakage, as specified in AWWA C561.
4. Top and side seals shall be self-adjusting ultra-high-molecular-weight polyethylene (UHMWPE) with compression cord and securely fastened to the

frame with formed stainless-steel retainers and shall be replaceable and adjustable in the field without disassembly of the frame and removing the gate from the installed position. The corners of the seals shall be vulcanized. Bottom seal to be UHMWPE.

a. When required for shutoff purposes, a neoprene top seal shall be mounted to the top member.

E. Yoke and Pedestal

1. The yoke, to support the operating bench stand, shall be formed by two structural members welded at the top of the guides to provide a one-piece rigid frame.

2. Self-contained gates shall be provided with a yoke to support the operating bench stand. The yoke shall be formed by two structural members welded at the top of the guides to provide a one-piece rigid frame. The maximum deflection of the yoke shall be L/360 of the gate's span.

2.3 LIFTING ASSEMBLIES

A. Stem and Couplings

1. The operating stem shall be of stainless steel designed to transmit in compression at least two times the rated output of the operating manual mechanism with a 40-pound effort on the crank. The operating stem shall be rising and shall be designed to withstand both tension and compression loads. For manual actuators the tension and compression design loads shall be those caused by the application of an 80-lb effort on the crank or handwheel or a 100- pound-foot torque on a wrench nut. The tension design load shall not exceed one-fifth of the ultimate tensile strength of the stem material. The compression design load shall be less than the critical buckling load as determined by AWWA C561.

2. Threads: Stems shall have rolled or American Standard general purpose full depth dual lead Acme type threads with a maximum roughness of 16 micro-inches. The stem shall be supported by angle guides or cast iron stem guides with a two-piece cast bronze guide collar, spaced to provide an L/R ratio of 200 or less.

3. 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.

4. Coupling: Stem lengths requiring more than one piece shall be joined together by stainless steel or bronze solid couplings. The couplings shall be threaded and keyed, threaded and bolted, or bolted only when one of the pieces is made of tubing and shall be of greater strength than the stem.

5. 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. The connection shaft shall be provided with a cover for safety.

6. Rising-stem gates with manual actuators shall be provided with a stop collar to be field adjusted according to the manufacturer's instructions at the time of gate installation to prevent over-closing the gate.

B. Stem Guides

1. Stem guides shall be fabricated from stainless steel. Stem guides shall be equipped with a UHMWPE bushing. Guides shall be adjustable and spaced in accordance with the manufacturer's recommendation. The L/R ratio shall not be greater than 200.

2. Stem guide brackets shall be provided as required to meet the stem design requirements specified in this section and may be mounted on the gate guides or yoke or may be wall mounted. Wall-mounted guides shall provide lateral adjustment between the wall and the guide bracket and between the guide bracket and the guide for field alignment. Guides which are mounted on the gate assembly shall be designed and fabricated to ensure proper alignment. Stem guide assemblies and their anchor bolts shall be designed to maintain the alignment under operating loads. Stem guides shall be equipped with a UHMWPE bushing with maximum diametral clearance of 1/8-inch.

C. Stem Cover

1. Rising stem gates shall be provided with a clear polycarbonate 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.

2.4 LIFTING MECHANISM

A. Operators of the types listed in the schedule shall be provided by the gate manufacturer.

B. Electric actuators are specified in Division 26.

C. 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 pounds on the crank, and shall be able to withstand, without damage, an effort of 80 pounds.

D. Gearboxes shall be provided when required to maintain the operating force below 40 pounds. All bearings and gears shall be totally enclosed in a weather tight housing. Operator housing shall be cast steel or cast iron. The pinion shaft of crank-operated mechanisms shall be supported by roller bearings. The operating shaft shall be fitted with a 2-inch square operating nut and removable crank. The crank shall be fitted with a corrosion-resistant rotating handle. The maximum crank radius shall be 15 inches and the maximum handwheel diameter shall be 24 inches.

2.5 ACCESSIBILITY

A. Crank or handwheel shall be located 36 inches to 42 inches above the walking surface. When required provide enclosed chain and sprocket drive to lower the actuator.

B. When crank is not accessible from the walkway provide horizontal extension and supports.

C. Grease zerks that are not easily accessible shall be extend to an easily accessible location.

2.6 MATERIALS

Part	Material
Slide, Spigot, Frame, Stiffeners, Yoke, Guide angles	Stainless Steel, AISI 316L
Side and Top seals	Ultra High Molecular Weight Polyethylene (UHMWPE), ASTM D4020
Invert seal	Ultra High Molecular Weight Polyethylene (UHMWPE) ASTM D4020
Bearing bars, Guides, Stem guide liner	Ultra-High Molecular Weight Polyethylene (UHMWPE) ASTM D4020
Bottom seal	Ultra-High Molecular Weight Polyethylene (UHMWPE), ASTM D4020
Threaded stem, Stem guides, tandem shafts, extension shafts	Stainless Steel, AISI 316L
Seal retainer	Stainless Steel, AISI 316L
Fasteners	Stainless Steel, ASTM F593/F594, Alloy Group 1
Pedestal/wall bracket	Stainless Steel, AISI 316L or Cast Iron ASTM A126, Class B or Mild Steel, ASTM A36/A36M
Stem cover	Polycarbonate ASTM A-707
Lift and stop nut	Manganese Bronze ASTM B584, UNS-C86500

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify the gates and all appurtenances meet the requirements of these Specifications.

3.2 INSTALLATION

A. The Contractor shall employ qualified competent personnel for the installation and testing.

B. Unless otherwise specified, gates shall be installed in accordance with manufacturer's instructions and AWWA C561.

C. Place concrete so that no voids occur around the frames or thimble, if present.

D. Securely anchor all materials embedded in concrete. Anchor bolts shall be carefully placed in templates for proper gate alignment. Use epoxied anchor where risk of spalling exists.

E. Verify that each guide is securely installed, and the gate operates smoothly. After gates have been properly installed, adjusted, and properly lubricated, each slide shall be operated for one complete cycle, open-close-open or close-open-close. Check for proper alignment and for indications of binding throughout a complete cycle. Gates showing excessive leakage shall be removed, remedied, and reinstalled until the excess leakage is no longer present.

F. Adjust and lubricate gate after installation.

G. After installation, perform a field leakage test to verify that the gate performs within the allowable leakage requirements of these Specifications.

H. Touch-up factory coatings damaged during shipping and construction.

3.3 FIELD SERVICE

A. One trip, one day: Inspection training and leakage testing.

END OF SECTION

SECTION 43 52 07
DAVIT CRANES

PART 1 GENERAL

1.1 SCOPE OF WORK

A. The Work of this section includes the furnishing and installation of permanent davit cranes, mounting sockets and accessories to be located throughout the project, as described below and shown in the Contract Drawings. Davit cranes shall be easily disassembled for storage or transport.

1.2 SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

B. Submit complete description literature, material lists and shop drawings.

PART 2 MATERIALS

2.1 DAVIT CRANE

A. General: The Construction Manager/General Contractor (CM/GC) shall furnish and install one davit crane with two wall mounts at Area 82 Solids Handling Building and two davit cranes at Area 05 Center St Lift Station. Davit cranes shall be supplied as shown on the Drawings and specified herein.

B. Schedule and Design Criteria

1. The davit cranes shall be installed shall meet or exceed the following criteria. Locate socket as directed in the following schedule and as shown on Drawings:

	Area 05 Center St Lift Station	Area 82 Solids Handling Building
Number of Cranes	2	1
Lifting Capacity	2000 pounds	650 pounds
Crane Model (or equal)	Thern Commander 2000	Thern Commander 500
Crane Material	304 SS	304 SS
Reach	82”	66”
Winch	4WP2 Electric Winch	Worm Gear Hand
Base	(2) Pedestal Mount 304 SS	(2) Wall Mounts 304 SS
Wire Rope (Length)	304 SS Cable (43’)	304 SS Cable (18’)

C. Crane, winch, and base socket parts such as castings, forgings, and stampings shall be designed with a safety factor of not less than five, based upon the ultimate strength of the material.

D. The winch shall have a quick disconnect anchor for quickly attaching or removing the wire rope from the winch drum.

E. The crane shall be able to rotate 360° load movement.

F. The crane shall include a rotational handle located on the mast at least 18-inches long and pinned at the connection point to the mast for ease of use and mobility.

G. Hand operated ratchet style screw-jack to adjust height and reach, for stationary crane.

H. The bases shall be supplied by the same Seller as the davit crane.

2.2 SELLER

A. The davit crane shall be Thern or approved equal, with modifications as needed to comply with this specification section.

B. The naming of a Seller in this specification is not an indication that the Seller's standard equipment is acceptable in lieu of the specified component features. Naming is only an indication that the Seller may have the capability of engineering and supplying a system as specified.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with the Seller's recommendations and as shown on the Drawings.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 46 41 16
SUBMERSIBLE MIXERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Equipment Tag References: 16-MX-201-3, 16-MX-202-3

B. Work described in this section includes providing all labor, equipment, materials, tools, and incidentals required for a complete and operable installation of the Submersible Mixer system as shown on the Plans and specified herein.

1.2 RELATED SECTIONS

A. Section 01 20 00 – Measurement and Payment

B. Section 01 33 00 – Submittal Procedures

C. Section 01 40 00 – Quality Requirements

D. Section 01 60 00 – Product Requirements

E. Section 01 65 00 – Commissioning of Systems

F. Section 01 78 23 – Operation and Maintenance Data

G. Division 03 – Concrete

H. Division 26 – Electrical

1.3 SUBMITTALS

A. Submittals shall be provided in accordance with Section 01 33 00.

B. Submit copies of all materials required to establish compliance with these specifications for review. Submittals shall include at least the following:

1. A copy of this specification acknowledging compliance or indicating deviation, for every paragraph of this specification. Indicate compliance by a “check” mark in the left-hand margin next to the paragraph. Indicate deviation by a “X” mark. For each deviation, provide an explanation and include supporting documentation to defend the position that the proposed change meets or exceeds the specified requirements. The submittal will not be reviewed without this specification markup. Engineer shall review the deviations as an “or-equal” or “substitution” request, as appropriate, in accordance with the General Conditions. The Engineer retains the right to reject the proposed deviation in favor of the specification as written.

2. Complete descriptive literature on the mixers, catalog cut sheets, engineering and physical data, and all accessory items necessary to fully describe and define all items, configuration, materials of construction, and other characteristics as required to document full compliance with these specifications.

3. Drawings showing dimensions of each unit.

4. The weight of the complete mixer assembly and each component; motor, gearbox, shafting and impellers.

5. Description of surface preparation, shop priming and finish painting of the mixer.

6. Mixer design calculations and process design calculations.

7. Complete motor data.

8. Power input requirements for mixers.

9. Motor horsepower and maximum current rating for each unit.

1. Complete bill of materials.

10. Service and warranty information.

11. Service and warranty information.

12. Mixer installation, operation, and maintenance manuals in accordance with Section 01 78 23.

13. Testing plan for field testing of mixers.

14. Copy of factory test results for vibration, shaft run out and motor power draw.

15. Copy of manufacturer's field start up report.

C. Reference: Provide plant name, location, contact person, and current telephone number.

D. CFD Modeling:

1. The mixer vendor shall use commercially available and widely used CFD modeling package such as STAR-CCM, FLOW-3D, or ANSYS (Fluent or CFX) for performing the modeling.

2. The CFD simulation will be performed to reach a steady-state solution taking no less than 5,000 iterations. In steady-state regime, the mixers are to be modeled by means of rotating reference frame model. In case that the specific geometry of the mixer body, through the rotating reference frame model, result in an inaccurate prediction of the steady-state behavior surrounding the mixer, a

transient (time dependent) simulation should be carried out after the steady-state simulation, using a model with real body motion, and providing the time averaged solution.

3. The mixer vendor should provide a CFD simulation in transient (time dependent) regime showing the residence time distribution of a tracer pulse using the frozen flow field of the previously obtained steady-state solution. The tracer pulse will be injected at the inlets for 5 seconds and the tracer concentration will be recorded at the outlets all time required until the tracer completely disappears from the basin.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Submit in accordance with 01 78 23.

B. Manufacturer's standard Operation and Maintenance Manual shall include the following sections:

1. Technical Data for the mixer package
2. Safety and Responsibility
3. Design and Function
4. Installation and Operating Conditions
5. Installation
6. Initial Start-up
7. Operation
8. Fault Recognition and Rectification
9. Maintenance
10. Spare parts, Operating Materials, Service
11. Decommissioning, Storage, and Transport
12. Appendix with Drawings and Diagrams

1.5 QUALITY ASSURANCE

A. Manufacturer's Qualifications

1. Manufacturer shall have a minimum of five years of experience producing equipment substantially like that required and shall be able to submit documentation of at least fifteen independent installations using the same size

or larger equipment as detailed below. Each installation must have been in satisfactory operation for at least five years.

2. The Contract Documents represent the minimum acceptable standards for the equipment. All equipment shall conform fully in every respect to the requirements of the respective parts and sections of the drawings and specifications. The entire unit shall be Manufacturer's standard product, but shall be modified, redesigned, furnished with special features or accessories, made of materials, or provided with finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of the specification.

3. Fabrication shall be done in compliance with all applicable ASTM standards or equivalent international standards.

4. Each mixer shall be completely shop assembled and factory tested to assure proper fit-up, acceptable limits of vibration, shaft run out, and motor power draw. The equipment shall then be packaged for shipment and jobsite storage to prevent damage or corrosion.

B. The equipment vendor shall be solely and fully responsible for warranty and mechanical design adequacy of all equipment provided under this section of the specifications.

C. Factory Tests

1. The mixer manufacturer shall perform the following inspections and tests on each mixer before shipment. The inspections and tests shall be executed under ISO 9001 certification.

   a. An insulation test of the windings.

   b. A balancing of the motor (rotor).

   c. A test of the mixer motor (run dry for five minutes at full load) to verify electrical data measurements. All electrical data shall be registered as part of documentation.

   d. The unit shall be run for 30 minutes submerged a minimum of 10ft under water to check the measurement of the electrical current on all phases.

   e. A motor and cable insulation test for moisture content and insulation defects.

   f. A dry test to verify correct rotation and mechanical integrity. The entire unit is checked for vibration.

   g. A final inspection of propeller, motor rating, and electrical connections for compliance with purchase order.

1.6 SPARE PARTS AND TOOLS

A. Furnish spare parts and any special tools required to perform normal routine maintenance and repairs for the first year of operation.

B. Furnish lubricants for the first year of operation.

1.7 WARRANTY

A. A written supplier's warranty shall be provided for the equipment system specified in this section. The warranty shall be for a minimum period of one year from Substantial Completion. Such warranty shall cover all defects or failures of materials or workmanship that occur as the result of normal operations and service.

B. The mixer manufacturer shall supply a Lifetime Warranty on the propeller which is inclusive of total replacement of the propeller blades should any damage, cracking, pitting of the propeller occur.

PART 2 PRODUCTS

2.1 BASIS OF DESIGN

A. Manufacturer used as the basis of design:

1. Wilo TR50-3.22-6/8

2. The manufacturer's representative is:

Brooks Proch

Ambiente H2O, Inc.

(720) 450-2523

bproch@ambienteh2o.com

B. Alternate manufacturers may participate in bidding as "or equals" only if pre-approved. Review as an "or equal" for pre-approval shall be in accordance with the procedures outlined in the General Conditions Article 7.05. Manufacturers listed below (as applicable) must meet or exceed this Technical Specification and related sections.

1. Pre-approved "or equals" are as follows:

a. KSB

b. ABS

c. Flygt

2. Manufacturers seeking to be listed as pre-approved shall provide a complete submittal for review by ENGINEER a minimum of 15 days prior to bid opening.

C. Substitution requests will not be reviewed during bidding.

2.2 GENERAL

A. The mixers provided in this section shall be furnished as a completed assembly, including, but not limited to, propeller, motor/propeller shaft, motor housing, motor casing cover, casing cover, O-rings / seals, fasteners, outer seal faces, inner seal faces, power cable jacket, guide rail (mast), support frame, mast mounting brackets, lifting cable, lifting davit, and oil (seal lubrication).

2.3 SERVICE CONDITIONS

A. Service: The submersible mixers shall be able of handling raw sewage and mixed liquor suspended solids. The tank dimensions are as shown on the construction drawings. The characteristics of the liquid are as follows:

	Anoxic Basin Mixers
Maximum Liquid Suspended Solids Concentration, mg/L	12,000
Specific Gravity of Solids	1.2
Average Side Water Depth, ft	16

2.4 PERFORMANCE REQUIREMENTS

A. Homogenization +/- 10 percent as measured by the results of a minimum of three total suspended solids concentration tests.

B. The mixers shall be of the integral design, close coupled, submersible type units. All components of the mixer, including motor shall be capable of continuous underwater operation. In addition, all components of the mixers shall be capable of continuous operation completely un-submerged for two (2) hours.

C. The mixers shall meet the following performance criteria at full speed:

Tag Number	16-MX-201-3, 16-MX-202-3
Basin TSS, %	1.5
Minimum Propeller Diameter, in.	19.69
Number of Propeller Blades	3
Maximum Propeller Speed, rpm	220
Minimum Circulation, gpm	4,280
Min Thrust, lbf	85.4
Maximum Motor Speed, rpm	1,080
Maximum Rated Motor, hp/unit	3.9
Motor voltage, v / phase	460 / 3
Minimum Motor Reserve at rated duty, %	57

2.5 MATERIALS

A.	Propeller	Stainless Steel, ASTM A276 Type 316 Ti
B.	Motor/Propeller Shaft	Stainless Steel, ASTM A276 Type 316 Ti
C.	Motor Housing	Cast Iron, ASTM A48, Class 40B
D.	Motor Casing Cover	Cast Iron, ASTM A48, Class 40B
E.	Casing Cover	Cast Iron, ASTM A48, Class 40B
F.	O-Rings / seals	Viton (FPM)
G.	Fasteners	Stainless Steel
H.	Outer Seal Faces	Silicon Carbide
I.	Inner Seal Faces	Silicon Carbide
J.	Power Cable Jacket	Chloroprene with non-wicking fillers
K.	Guide Rail (Mast)	Stainless Steel, ASTM A276 Type 304 or 316
L.	Support Frame	Cast Iron, ASTM A48, Class 40B
M.	Mast Mounting Brackets	Stainless Steel, ASTM A276 Type 304 or 316

N.	Lifting Cable	Stainless Steel, ASTM A276 Type 304 or 316
O.	Lifting Davit marine-grade winch	Stainless Steel, ASTM A276 Type 304 or 316 with
P.	Oil (seal lubrication)	Environmentally safe, mineral or paraffin base

2.6 MIXER CONSTUCTION

A. GENERAL

1. The mixers shall be the submersible type and shall be installed in location as shown in the plans.

2. All mating surfaces of the major castings requiring a watertight seal shall be machined and fitted with O-rings.

B. MIXER HOUSING

1. All major components of the mixing unit (i.e. stator housing, seal housing, and cable entry) shall be manufactured from close-grained ASTM A48 Class 35 or higher (GG25) cast iron.

C. PROPELLER

1. Propellers shall be investment casted. No welded steel or stainless steel propeller shall be accepted.

2. The propeller shall have a swept-back profile and three (3) blades. The blades shall be smooth, finished throughout, and shall be free from sharp edges.

3. Propellers shall be statically and dynamically balanced.

4. Propellers shall be slip fit and securely held to the shaft by a stainless steel washer and bolt assembly that is enclosed in a separate hub chamber. The hub chamber is fitted with an O-Ringed cap that seals the entrance of the propeller hub chamber device. The output shaft shall be splined to mate with the matching spline insert of stainless steel that forms the hub of the propeller.

D. PROPELLER SHAFT

1. The shaft connecting the propeller to the gear reducer shall be constructed of AISI 329 (1.4462) stainless steel.

2. Minimum propeller shaft diameter (D), measured at the outermost bearing shall be 1.77-in (45-mm).

3. The propeller shaft shall be supported such that the length (L) from the outermost bearing to the hub of the propeller shall not exceed 3.88-in (98.5-

mm). The shaft overhang ratio of the distance from the bearing to the hub of the propeller (L) divided by diameter of the shaft at the bearing shall not exceed 2.2.

E. BEARINGS

1. Each mixer shall be furnished with a minimum of four (4) sets of bearings spaced to minimize shaft deflection to offer maximum bearing life. At a minimum, at least two sets of the bearings shall be of double row design. Designs with fewer than four (4) sets of bearings shall not be allowed.

2. A minimum of two sets of bearings shall support the propeller shaft (shaft from gear box to the propeller). Designs where the propeller shaft is supported solely by the gearbox shall not be acceptable.

3. Mixer shaft overhang and bearing design shall provide a minimum B-10 life of 100,000 minimum per ISO 281:2007-02, at rated duty.

4. Bearings shall be sealed, grease lubricated and maintenance-free.

F. MECHANICAL SEALS

1. Each submersible mixer shall be provided with two separate seal chambers. The inner chamber shall be located between the dry stator chamber and the gear reduction chamber. The outboard seal chamber shall be located between the gear reduction chamber and the outside of the mixer at the hub of the propeller.

2. Each seal chamber shall be provided with an independent set of mechanical seals and a lip seal running in an oil bath. The inboard set of seals shall be mounted in the chamber between the motor and gearbox. The outboard set of seals shall be mounted between the gearbox and the propeller.

3. Each mechanical seal set shall be provided on both the stationary and rotating components. Other materials, such as tungsten carbide or ceramic, are prohibited.

4. The metal components of the mechanical seal case shall be constructed of AISI 316 stainless steel.

5. A moisture sensor probe shall be furnished in the outboard seal oil chamber of each mixer. The sensor shall be wired to the control panel and shall activate an alarm light upon moisture intrusion.

6. The outboard seal sensor probe shall be externally located and accessible for maintenance without the need to disassemble the mixer for service or replacement.

G. GEAR REDUCER

1. The motor shall drive the submersible mixer propeller through a planetary gear reduction drive system that locates the motor shaft in line with the propeller shaft.

2. The motor shaft shall be fitted with a keyed sun gear that uses high efficiency straight cut teeth to engage the planetary gear section.

3. The sun gear system shall be custom matched to the planetary gear system to allow for propeller speed changes in the field by a simple exchange of the sun gear and the planetary gear plate.

4. The planetary gear section shall consist of three identical gears mounted on a stainless steel backing plate designed to withstand 100% lock stress from the propeller without gear or bearing damage.

5. Each planetary gear shall be supplied with precision needle bearings, which are lubricated by the gear lubricant in the gear chamber.

6. There shall be a minimum of three planetary gears spaced 120 degrees around the central sun gear.

7. The planetary gear section shall be easily removed and shall be interchangeable with other ratios and for simplified spare parts inventory.

8. The planetary gear section shall also engage a ring gear mounted in the outer surface of the gear chamber, which shall cause the motor rotation to also rotate the planetary gear plate that shall be fitted to the output propeller shafting by the use of a straight splined connection.

9. The planetary gear plate shall be retained on the output propeller shaft by the use of a snap ring and snap ring groove in the output shaft.

10. The planetary design shall be designed such that with regular oil changes, no further maintenance should be required during the life of the submersible mixer in the installation. The gears shall have a minimum L-10 life of not less than 100,000 hours at the rated duty.

11. Gear oil changes shall be easily made using external stainless steel pipe plugs that are sealed via nylon washers.

12. Standard 80 to 90-weight gear oil either normal or synthetic shall lubricate the gear section.

2.7 MOTOR

A. SUBMERSIBLE MOTORS

1. Each mixer shall be furnished with a squirrel cage, induction motor enclosed in a watertight housing suitable for use and compatible with all variable frequency

drive systems. The air-filled motor design shall be liberally sized for efficient heat transfer via the motor housing to dissipate within the fluid surrounding the mixer unit during normal operation. All mixer motors shall be rated for continuous operation.

2. The motor shall be air-filled and constructed with moisture resistant NEMA Class H insulation and Class H slot liners and constructed to NEMA B design standards. The copper wound stator shall be dipped in epoxy enamel and hardened to withstand a temperature of 180 °C as defined in NEMA Standard MG-1. Each winding phase or layer shall be laced with Class H glass lined paper. The use of cable ties to restrain windings shall not be allowed. The rotor shall be statically and dynamically balanced after fabrication. The rotor shall utilize aluminum amortisseur bars and short circuit rings. The constructed motor shall be certified for continuous duty with a service factor of 1.10 on sine wave power.

3. Motors shall be capable of sustaining 15 starts per hour (unlimited starts with VFD) at an ambient temperature of 40°C.

4. Motors shall be capable of uninterrupted operation with a voltage drop of 10%.

5. Thermal switches shall be furnished to monitor stator temperatures. The stator shall be equipped with two (2) thermal switches. Thermal switches shall automatically de energize the motor when its temperature exceeds a preset limit as recommended by the manufacturer.

6. The motor shall bear the FM (Factory Mutual) explosion-proof label certifying its use in a Class 1, Division 2, Groups C & D hazardous location.

7. The manufacturer's nameplates shall be engraved, laser etched or stamped on stainless steel and fastened to the motor casing.

B. SHAFTS

1. The shaft shall be one-piece construction without joints or stubs attached.

2. Minimum shaft diameter shall be 1.375-in (35-mm) at the double bearing motor shaft bearing.

C. POWER AND CONTROL CABLES

1. Power and control cables shall be furnished in lengths to run un-spliced from the mixer to the control panel or disconnect as shown on the Contract Drawings and as specified herein (49-ft). Cables shall terminate with conductor sleeves that bundle the entire group of strands of each phase to improve termination at the pump control panel. The sleeves shall be provided to confirm that all strands of each conductor are terminated properly.

2. Cables shall be of the "NSSHOU" type and shall be approved by the MSHA for use in hazardous locations and shall conform to industry standards for loads, resistance under submersion against sewage, and be of stranded construction. The cables shall enter the mixer motor through a heavy-duty galvanized cast iron entry assembly that shall be provided with an external clamp assembly to protect against tension once secured providing a strain relief function as part of standard construction.

3. The cables for each mixer motor shall pass through the galvanized cast iron strain relief component and then through a series of stainless steel disks and Buna-n grommet that is sandwiched between the disks to control compression of the grommet. The cable entry design shall be of the type recommended in the Factory Mutual Research Corporation specifications for Explosion Proof Certification. The entry shall be comprised of the cast iron fitting that will include the Buna-N strain relief grommet coupled with a poured conductor section. In the poured section, only Factory Mutual approved sealant shall be used to wick into each conductor strand that has the insulation removed in this area to provide a positively leak-proof seal for the power and sensor cords.

2.8 REMOVAL SYSTEM

A. GUIDE RAIL (MAST) SYSTEM

1. Where called for on the drawings and to accommodate ease of removal, a guide rail shall be used to mount each mixer during operation and to guide the units during installation and removal for service. The system shall consist of a bottom assembly, mixer support assembly, 80-mm by 80-mm guide pipe, upper support and positioning device. The system shall be fixed at the bottom of the tank in a pivot that shall allow horizontal rotation of the mast through not less than 120 degrees. The mast bearings shall be constructed of Hostaform (POM). Electrical motor cable holders shall be provided per manufacturer's recommendation.

2. The bottom assembly shall be bolted to the floor of the tank and provide support for the guide pipe. It shall also include a hole to accept the guide pipe bottom plug.

3. The assembly shall be strong enough to support the weight of the mixer, the guide pipe and the mixer preload force. The assembly shall be positioned in such a manner to prevent the mixer propeller tips from hitting the basin floor. The mixer shall rest upon a support foot.

4. The upper guide holder assembly shall secure the system to the tank edge or platform. It shall also provide the lateral support for the guide pipe. The assembly shall contain a location to secure the electrical motor cable holder.

B. HOIST (CRANE) ASSEMBLY

1. A hoist system shall be used for lifting and lowering of the mixer on the guide rail during installation and maintenance. The system shall be capable of 360

degree-rotation. Each hoist assembly shall be rated at a minimum of 250-kg (550-lb). The sleeves and the bearings in the receiving box shall be constructed of Nylon (polyamide).

2. To optimize mixing and minimize fouling the propeller shall be completely open to the mixed media. Diffuser devices such as jet rings and shrouds should typically be avoided. Each blade shall be contoured such that the tangent line at any point on the leading edge is equal or less steep relative to the circumferential direction than the resulting force, causing fibrous materials to always slide toward the outer radius of the propeller.

3. The propeller shall be capable of handling solids and fibrous materials, heavy sludge, and other matter found in normal sewage applications.

2.9 SHOP PAINTING

A. Primer and Finish Paint-Shop apply to all exterior ferrous surfaces of the mixer and motor.

1. Solids by volume: 97%

2. Type: Solvent-free ceramic coating, impregnated with aluminum oxides

3. Total Dry Film Thickness: 400 microns (15 mils) minimum

4. Minimum Adhesion: 15 Newtons per square millimeter (2,030 psi) per ISO 4624.

5. Minimum Hardness: 110 on Buchholz Indentation scale

6. Resistance: Level 1 (continuous duty) for sewage with pH of 6-11.

B. Surface Preparation-Prepare all surfaces to receive coating system.

1. Method: Blasting per ISO 12944-4

2. Standard Cleanliness Grade: 2.5

3. Minimum Peak to Valley Height: 70 microns (2.75 mils)

PART 3 EXECUTION

3.1 PRODUCT DELIVERY, HANDLING, AND STORAGE

A. Delivery and Handling of Equipment:

1. Manufacturer and Contractor shall coordinate the delivery schedule for the project schedule.

2. Contractor shall unload and inspect all equipment and materials against reviewed shop drawings at the time of delivery. Any damage shall be reported to the freight company immediately upon receipt.

3. Equipment and materials damaged or not meeting the requirements of the reviewed shop drawings shall be immediately returned for replacement or repair.

4. Each box or shipping crate shall be properly marked to show its net weight and its contents.

B. Storage:

1. Contractor shall prepare for storage and label all equipment and materials after they have been inspected. The Contractor shall be responsible for the equipment and materials while in storage.

2. Store materials to permit easy access for inspection and identification.

3. Support all material off the ground while protecting steel members and packaged material from corrosion and deterioration as per manufacturers' instructions.

C. Examination:

1. Verify all equipment and materials are present and meet the requirements of these Specifications.

3.2 INSTALLATION

A. Installing Contractor shall install the equipment specified herein in accordance with the Manufacturer's requirements. Vendor shall provide assistance and clarification as required during installation.

B. Installation of the equipment shall be in strict accordance with the Contract Documents and the manufacturer's instructions and shop drawings.

C. The Contractor shall be responsible to verify the accuracy of all dimensions in the field and to ensure compatibility with the specifications and equipment.

D. The Contractor shall lubricate the mechanical equipment prior to initial operation.

E. The Contractor shall be responsible for completing the first scheduled lubrication services after the equipment has undergone the initial break-in period according to the manufacturer's recommendations for stated run-time hours.

F. After the equipment is installed, the vendor shall provide a factory trained, experienced, competent, and authorized representative to inspect the installation, generate a

deficiency list for the Installing Contractor, and assist in correcting any deficiencies with the installation.

G. Vendor's representative shall provide a minimum of one day (8 hours on-site per day minimum) of on-site assistance for installation. If additional time is required to assist with the installation, it shall be at no additional cost to the Owner.

3.3 COORDINATION OF RELATED EQUIPMENT

A. Contractor shall carefully coordinate equipment, motors, drives, and controllers so that the completed system operates satisfactorily under all operating conditions.

3.4 FIELD QUALITY CONTROL

A. Initial Starting and Testing of Systems

1. Vendor's representative shall provide a minimum of one day (8 hours on-site per day minimum) of on-site assistance for initial starting and testing of systems. If additional time is required to assist with the initial starting and testing of systems, it shall be at no additional cost to the Owner.

B. Acceptance Testing

1. Seller's representative shall provide a minimum of one day (8 hours on-site per day minimum) of on-site support for acceptance testing.

2. Acceptance testing shall be completed with the treatment basins in service with MLSS concentrations at 6,000 mg/L minimum.

3. The mixers shall be field tested in the presence of the Engineer to verify that operation is satisfactory and in compliance with the Specification.

C. If the mixer package does not meet the requirements of this Specification, corrective measures shall be taken, and re-testing undertaken to confirm compliance with the Contract Documents at no cost to Owner.

3.5 COMMISSIONING EQUIPMENT

A. Perform commissioning per Section 01 75 016.

3.6 TRAINING

A. Seller's qualified service representative shall provide a minimum of one day (8 hours on-site minimum) of training of the Buyer's staff for operation and maintenance of the equipment.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 46 51 21
COARSE BUBBLE DIFFUSED AERATION SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

A. All labor, materials, and equipment for a coarse bubble aeration system in the new solids holding tank 80-TK-1100.

1.2 RELATED SECTIONS

A. Section 01 20 00 – Measurement and Payment

B. Section 01 33 00 – Submittal Procedures

C. Section 01 40 00 – Quality Assurance and Quality Control

D. Section 01 65 00 – Commissioning of Systems

E. Section 01 73 00 – Operation and Maintenance Data

F. Division 3 – Concrete

G. Division 26 – Electrical

H. Section 43 12 10 – Positive Displacement Solids Handling Blowers

1.3 SUBMITTALS

A. A list of the three most recent installations where similar equipment by the manufacturer has been in successful operation for a period of not less than five years. Include contact name, telephone number, mailing address, and the names of the Engineer, Owner, and installation contractor. If three installations do not exist, the list shall include all that do exist, if any.

B. Equipment that would require changes in the design shall also include detailed information on structural, electrical, mechanical, process specifics, and other miscellaneous changes or modifications necessary to adapt their equipment to the arrangement shown. All costs incurred by the Engineer to make these design changes and modifications shall be reimbursed by the Bidder.

C. Letter from equipment manufacturer certifying the system being provided will not infringe on any patents.

D. Requirements for storage and protection prior to installation.

E. Submit a copy of this specification section, with addendum updates included, with each paragraph clearly marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. If deviations from the specifications are indicated and therefore requested by the Contractor, the submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification for any requested deviations to the specification requirements, with the submittal shall be cause for rejection of the entire submittal with no further consideration. The Owner retains the right to reject any proposed deviations in favor of this specification, as written.

F. Submit shop drawings showing plan, elevation, and appropriate cross sections of the aeration equipment; diffuser connectors, supports, expansion joints, and flanges; and anchor details for use in the basin. Verify all basin dimensions and include in the shop drawings.

G. Complete headloss calculations for the aeration equipment from the manufacturer's point of responsibility.

H. Operation and maintenance manuals with installation instructions to be submitted after the aeration equipment has been released for fabrication by the Engineer and Contractor and prior to shipment.

I. Manufacturer's certificate of proper installation.

J. Airflow (scfm) required to meet performance requirements specified for initial and future conditions.

1.4 DEFINITIONS

A. Actual Oxygen Transfer Rate (AOTR): Actual rate of oxygen transfer in wastewater required under actual operating conditions to satisfy biological uptake.

B. Adequate Mixing: Variation in suspended solids (total residue) of less than 10% between the mean value of samples taken at any two depths along any vertical line extending between water surface and the top of diffusers.

C. Basin: Structure within which aeration occurs.

D. Distribution Header: Piping between manifold and diffuser assembly.

E. Dropleg: Connection from air source to manifold.

F. Dynamic Wet Pressure: Pressure to operate at specified conditions minus submergence and flow control losses.

G. Grid: Configuration of diffuser system in each basin.

H. Manifold: Single run of piping that connects dropleg with distribution header(s).

I. Standard Cubic Feet per Minute (scfm): Air at 68° F, 14.7 psia, and 36% relative humidity.

J. Standard Oxygen Transfer Rate (SOTR): Rate of oxygen transfer to tap water at standard conditions of 20° C, 0.0 mg/L residual dissolved oxygen concentration, and a barometric pressure of 760 mm Hg (dry air).

K. Standard Oxygen Transfer Efficiency (SOTE): Standard oxygen transfer efficiency is understood to be the percentage of the oxygen in the air supplied that is transferred into a solution of tap water under standard conditions of 20° C, 0.0 mg/L residual dissolved oxygen concentration, and barometric pressure of 760 mm hg (dry air).

L. Sidewater depth: Sidewater depth is understood to be the interior dimension from the structure base to the water surface. This may vary at different points in the basin due to sloping floor slabs.

M. Submergence: Submergence is the depth from the discharge surface of the diffuser to the water surface.

1.5 SYSTEM PERFORMANCE AND DESIGN

A. General

1. It is the intent of the Owner that the Contractor furnish and install a coordinated, completely engineered system suitable for the operating conditions as outlined in these Specifications for use in the basin as indicated in the Contract Documents.

2. Details such as air manifolds, header supports and spacing, diffuser spacing, expansion provisions, etc., shall be defined by and be the responsibility of the manufacturer and shall be consistent with all requirements imposed in this Section.

3. Functionally, the process aeration equipment shall be suitable for aeration service and application in outside, uncovered, concrete basins. In addition, the equipment shall be structurally and mechanically designed to reliably perform in this application without corrosion or other types of failure. The equipment shall function to evenly distribute air and achieve levels of oxygen transfer specified herein.

4. The proposed equipment shall conform to the approximate layouts shown on the Plans and shall not require power, instrumentation and control, water, or other support services other than what is shown. Orientation of the equipment within each basin shall be the responsibility of the equipment supplier and the Contractor.

B. Design Conditions

1. The influent to the tank consists of waste activated sludge from an extended aeration membrane bioreactor process. The aeration equipment shall mix and entrain oxygen in the basin contents by diffusing air into the mixed liquor.

2. The solids holding tank consists of one circular tank as shown in the Drawings. One 8" drop leg will deliver the required air flow to the basins. The water level will be the same throughout the basin.

3. The solids holding tank has the following general characteristics:

Tank Diameter .....60 ft

Side Wall Tank Height .....18 ft

Side Water Depth Operating Range..... 4 to 15.5 ft

Diffuser Submergence ..... 3.5 to 15 ft

Waste Activated Sludge Concentration..... 6,000 to 20,000 mg/L

Site Elevation.....4,810 ft (AMSL)

Waste Activated Sludge Temperature.....10 to 25° C

4. The aeration system shall be designed to deliver the following performance:

   a. Total Air Flow Rate .....1272 scfm (@14 ft side water depth)

   b. Maximum Pressure at Top of Dropleg = 7.40 psig

   c. Minimum Drop-Leg Pipe Diameter = 8"

5. Provide the piping arrangement and diameters as shown in the drawings. The minimum quantity of stainless-steel wide band diffuser units in the tank shall be as follows. Additional diffusers shall be provided, as necessary, to achieve the specified performance requirements.

   a. 52 diffusers

1.6 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts:

1. Three (3) complete diffuser assemblies with connecting hardware, as appropriate.

B. Furnish other commonly required spare parts and special tools required to remove and replace diffusers. Tools will be furnished in a steel tool box clearly labeled according to its contents with an indelible marker.

1.7 PATENTS

A. The manufacturer shall warrant that this equipment will not infringe on any U.S. or foreign patent. A letter from the manufacturer so certifying shall be submitted.

1.8 WARRANTY

A. Warrant all parts to be free from defects in materials and workmanship for a period of one (1) year from substantial completion.

B. Furnish replacement parts to the Owner for any items found to be defective within the 1-year warranty period.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Manufacturers: Provide a coarse bubble aeration system meeting the requirements of this specification from one of the following. Manufacturers meeting the requirements of this specification but not listed here may be considered in accordance with the Contract Documents and the Instructions to Bidders.

1. EDI Environmental Dynamics Internationals
2. Sanitaire Water Pollution Control Corporation
3. Aquarius Technologies, Inc.

B. The manufacturer shall have experience in the design, manufacturing, supplying and commissioning of coarse bubble aeration equipment of the type specified for this project. The equipment quoted shall be of a proven design and shall be referenced by at least three installations of similar size, having been in successful operation for a period of not less than five years.

2.2 MATERIALS, FABRICATION and FINISHING

A. Stainless Steel

1. Fabricate all welded parts and assemblies from sheets and plates of 304L stainless steel with a 2D finish conforming to ASTM A240.
2. Fabricate non-welded parts and pieces from sheets, plates, or bars of 304 stainless steel conforming to ASTM A240 or ASTM A276.
3. Provide drop legs, manifolds, and headers of the diameter shown on the drawings with dimensional tolerances conforming to ASTM A554 and fabrication procedures in accordance to ASTM A774 and A778.
4. Furnish air distribution headers with the following minimum nominal wall thicknesses.
   a. For gusset-reinforced diffuser connectors and header systems as specified in Section 2.3.E.

Header Diameter	**Wall Thickness**
(Inches)	**(Inches)**
4 Thru 18	0.109

   b. For diffuser connectors and headers that are not gusset reinforced as specified in Section 2.3E, the minimum allowable header wall thickness is 0.25 inches to minimize potential for connector failure.
5. Furnish diffuser connector from cast 316L stainless steel.
6. Furnish all flanges from stainless steel per paragraph 2.2.A.2.

7. Furnish all nuts, bolts, and washers, including anchor bolts, in 18-8 series stainless steel.

8. Furnish 304L stainless steel diffusers conforming to the material as listed in paragraph 2.2.A 1,2, and 3 with a cast 304L schedule 80 threaded inlet nozzle.

9. Welds and Welding Procedure

    a. Weld in the factory with ER 316L filler wire using MIG, TIG or plasma-arc welding inert gas processes. Provide a cross section equal to or greater than the parent metal.

    b. Provide full penetration butt welds to the interior surface with gas shielding to interior and exterior of joint.

    c. Provide smooth, even distribution interior weld beads with an interior projection not exceeding 1/16 inch beyond the I.D. of the air header or fittings.

    d. Continuously weld both sides of face rings and flanges to eliminate potential for crevice corrosion.

    e. Field welding is not permitted.

10. Corrosion Protection and Finishing: Clean all welded stainless-steel surfaces and welds after fabrication by using the following procedure:

    a. Pre-clean all outside weld areas to remove weld splatter with the use of stainless-steel brushes and/or deburring and finish grinding wheels.

    b. Finish clean all interior and exterior welds and piping by full immersion pickling and rinse with water to remove all carbon deposits, oxide film, and contaminants to regenerate a uniform, corrosion resistant chromium oxide film.

        i. Completely immerse all stainless-steel assemblies and components in an acid solution as described in Section 6.2.11 of ASTM A380. Use nitric-hydrofluoric acid solution as defined in Table A.2.1 of Annex A2 of ASTM A380.

        ii. Provide a final thorough rinse using ordinary industrial or potable water and dry in conformance per Section 8.3 of ASTM A380.

    c. Corrosion protection techniques not utilizing full immersion methods are unacceptable and will be cause for rejection of the equipment.

    d. Engineer/Owner at their option may choose to observe the equipment cleaning procedure by notifying the manufacturer of their intent to visit thirty (30) days prior to the date. Cost of the travel and expenses are by the Owner.

B. Neoprene: Furnish all gaskets of fiber reinforced neoprene – 45 to 50 durometer (Shore A).

2.3 FIXED AERATION HEADERS, MANIFOLD AND DROPLEGS

A. Provide a drop leg from the air main connection or air control valve to the aeration system

as shown on the drawings.

1. Provide a Van Stone style flange design with a 150 pound drill pattern for the top connection.
2. Provide a band clamp coupling with gasket for the lower dropleg to header connection for ease of installation and alignment.

B. Fabricate manifold and air distribution headers in sections up to 41 feet in length.

1. Provide eccentric reducers for changes in diameter for constant invert elevation.
2. Provide 8-inch diameter and smaller headers with removable end caps and 10-inch diameter and larger headers with welded end caps.

C. Join sections of manifold or air distribution headers with flanged joints or expansion joints. Design individual header sections for rotation independent of adjacent sections for alignment purposes during installation.

1. Provide flanged joints consisting of face rings, rotating ring flanges, bolts, and gaskets.
2. Provide expansion joints consisting of a welded flanged expansion barrel, "O" ring gasket, "O" ring locking flange and hardware to accommodate $\pm$2 inch of movement.

D. Furnish expansion/contraction system for all headers designed for temperature range of 125° F consisting of simple and fixed supports and expansion joints.

1. Lengths of header can extend up to 80 feet from restraining point without an expansion joint.
2. Limit maximum distance between restraining points on a continuous length of header to 120 feet maximum.
3. Provide an expansion joint on continuous lengths of header between two restraining points.
4. Provide simple supports to restrain header from buoyant uplift forces in compliance with Section 2.4.
5. Provide fixed supports in compliance with Section 2.4.
    a. Limit movement to prevent expansion joint blow apart and transmit expansion forces from the header to the fixed support stand.
        i. Provide a mechanical link to connect the header and fixed support stand.
        ii. Reinforce the header at the attachment point of the mechanical link.

E. Duplex Diffuser Connectors

1. Factory weld to the invert centerline of the air header.
2. Design diffuser connectors for two diffusers.
3. Furnish PVC plugs for all unused diffuser connectors.
4. Provide connectors of length appropriate to the header diameter and positioned so that air exiting the diffusers clears the header.
5. Design header and diffuser connectors as follows:
    a. Reinforce the connector header weld joint by providing gussets continuously welded between the vertical sidewall of the header and the connector ends to limit long-term flexure failure. Minimum gusset thickness is 0.125 inch.
    b. Weld connector to the header with a full penetration butt weld to minimize potential for crevice corrosion between header and connector. Use of fillet welds at the connection between the diffuser connector and header is not permitted.
    c. Resist a vertical dead load applied to the threaded end of the connector that results in a bending moment of 1,000 inch-lbs without exceeding 24,000 psi design stress in any part of the header wall or connector.
    d. Header wall thickness for unreinforced connectors must comply with Section 2.2.A.4.b.

2.4 SUPPORTS AND ANCHOR BOLTS

A. Provide each section of air header with a minimum of two supports with the maximum spacing between supports not to exceed 17 feet-6 inch.

B. Limit header or manifold cantilever to no more than 4 feet.

C. Provide header supports with a vertically adjustable header hold down locking mechanism mounted on a stainless steel support structure.

D. Design support hold down locking mechanism to resist uplift forces without exceeding 40,000 psi design stress.

E. Design support hold down as follows:

1. For headers 12-inch diameter and less, provide 2-inch-wide x .109-inch-thick strap or 3/8-inch-diameter rod.
2. For headers 14-inch diameter and larger, provide ½-inch-diameter rod.

F. Provide supports with a mechanism to allow for $\pm$2 inch of vertical adjustment and $\pm$1/4 inch of lateral adjustment for alignment of the header.

G. Provide a wall or floor mounted support near the drop pipe to header connection for vertical support and restraint of movement due to thermal expansion and to prevent blowing apart.

H. Provide a stabilizer strut for all supports when header centerline exceeds 1 ft.-10 in.

I. Anchor Bolts

1. Design anchor bolts for embedment in 4000 psi concrete with a pullout safety factor of 4.
2. Attach supports to the tank with two stainless steel anchor bolts.
3. Provide a mechanical stainless steel expansion type anchor bolt system.

J. Supports shall be designed to allow for complete removal from the tank (less anchor bolts) to facilitate cleaning and maintenance of the tank bottom.

2.5 AIR DIFFUSERS

A. Provide diffusers fabricated of stainless-steel material – refer to Section 2.2 Materials, Fabrication and Finishing.

B. Design diffuser for operating range of 8 to 40 SCFM.

C. Design diffusers with cast schedule 80 – 3/4 inch NPT threaded nozzle and acetyl orifice insert if required, an inverted air reservoir, air exit ports and a full-length deflector.

1. Design diffusers to provide full wide band aeration with a minimum air release perimeter of 48 inches per diffuser. Release air uniformly along a minimum 2-foot band beyond each side of the header.
2. Locate exit ports discharging air into liquid on horizontal planes at two levels.

D. Diffuser Deflector

1. Provide deflector below each diffuser for its full length and width.
2. Design deflector to direct the liquid being aerated along the diffuser reservoir walls so that the air exits through the ports and is sheared into small bubbles and distributed into the liquid.

PART 3 EXECUTION

3.1 INSTALLATION PROCEDURE

A. Follow equipment manufacturer's recommendations for sequencing of equipment installation.

B. Layout and install support anchors in accordance with equipment manufacturer's

recommendations and anchor setting plan.

C. Level aeration system such that all diffusers connected to a header are within plus or minus 3/8 inch of a common horizontal plane.

3.2 INSTALLATION/STARTUP SERVICES

A. Provide services of a factory representative familiar with the installation of coarse bubble aeration equipment for one (1) day to assist and verify the proper installation of the equipment and to instruct the Owner's personnel in the operation and maintenance of the equipment.

END OF SECTION

SECTION 46 51 29
FINE BUBBLE DIFFUSED AERATION SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Fine bubble diffusers for Process Train No. 3. Per the Drawings, the Aerobic Basins in which the diffusers shall be installed are:

Process Train No. 3
Aerobic Basin 16-TK-401-3
Aerobic Basin 16-TK-402-3
Aerobic Basin 16-TK-403-3

B. Work described in this section includes providing all labor, equipment, materials, tools, and incidentals required for a complete and operable installation of the Fine Bubble Diffuser system as shown on the Plans and specified herein.

1.2 RELATED SECTIONS

A. Section 01 22 00 – Measurement and Payment

B. Section 01 33 00 – Submittal Procedures

C. Section 01 40 00 –Quality Requirements

D. Section 01 60 00 – Product Requirements

E. Section 01 65 00 – Commissioning of Systems

F. Section 01 78 23 – Operation and Maintenance Data

G. Division 03 – Concrete

1.3 REFERENCES

A. ASTM A240: Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

B. ASTM D1784: Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds

C. ASTM D1785: Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

D. ASTM D1869: Rubber Rings for Fiber-Reinforced Cement Pipe

1.4 SUBMITTALS

A. Submittals shall be provided in accordance with Section 01 33 00.

1. A copy of this specification acknowledging compliance or indicating deviation, for every paragraph of this specification. Indicate compliance by a “check” mark in the left-hand margin next to the paragraph. Indicate deviation by a “X” mark. For each deviation, provide an explanation and include supporting documentation to defend the position that the proposed change meets or exceeds the specified requirements. The submittal will not be reviewed without this specification markup. Engineer shall review the deviations as an “or-equal” or “substitution” request, as appropriate, in accordance with the General Conditions. The Engineer retains the right to reject the proposed deviation in favor of the specification as written.

B. Submittals shall include, but not be limited to, the following:

1. Manufacturer’s catalog data.

2. Dimensional drawings for all equipment including the air feed main, air distribution main, and diffuser assemblies indicating materials of construction, number, spacing, location of diffusers, layout and size of air feed, distribution mains, and anchor details.

3. Description and dimensional drawing showing the proposed method of supporting the air feed and distribution piping as required to prevent uncontrolled movement due to flotation and dynamic forces.

4. Descriptive literature and dimensional drawings showing the proposed method of compensation for thermal expansion and contraction in the aeration system.

5. Method of purging / draining water from the aeration system piping when the aerobic zones are full of liquid.

6. Oxygen transfer calculations including airflow (scfm) required to meet performance requirements specified for the following conditions:

    a. Annual average loading

    b. Maximum month loading

    c. Peak day loading

7. Head loss calculations for the air diffusers, flow control orifices, and system piping for the following conditions:

    a. Annual average loading

    b. Maximum month loading

c. Peak day loading

8. Oxygen Transfer Test Results: furnish testing data from a independent testing laboratory showing the performance of the diffusers in clean water (previous tests, if conducted within the past 5 years, are acceptable). Minimum oxygen transfer shall be 30 percent at 15.2-feet submergence in clean water at standard conditions (20 degrees C, zero mg/L DO, an alpha factor of 1.0, beta factor of 1.0- and 760-mm Hg). Diffuser spacing, average air flow rate and all other properties for the test diffusers shall be essentially identical to those of the full-scale installation. A minimum of 3 test runs shall be made.

9. Materials and manufacturing specifications including a table of EPDM material characteristics demonstrating compliance with this specification.

10. Membrane longevity test reports in accordance with this specification.

11. Requirements for handling and storage.

12. Installation instructions shall be submitted after the aeration equipment has been released for fabrication.

1.5 OPERATION AND MAINTENANCE MANUALS

A. Submit in accordance with 01 78 23.

B. Manufacturer's standard Operation and Maintenance Manual shall include the following sections:

1. Technical Data for the fine bubble diffuser package

2. Safety and Responsibility

3. Design and Function

4. Installation and Operating Conditions

5. Installation

6. Initial Start-up

7. Operation

8. Maintenance

9. Spare parts, Operating Materials, Service

10. Decommissioning, Storage and Transport

11. Appendix with Drawings and Diagrams

1.6 QUALITY ASSURANCE

A. Manufacturer shall have a minimum of five years of experience producing equipment substantially like that required and shall be able to submit documentation of at least fifteen independent installations using the same size or larger equipment as detailed below. Each installation must have been in satisfactory operation for at least five years.

B. The Contract Documents represent the minimum acceptable standards for the equipment. All equipment shall conform fully in every respect to the requirements of the respective parts and sections of the drawings and specifications. The entire unit shall be Manufacturer's standard product, but shall be modified, redesigned, furnished with special features or accessories, made of materials, or provided with finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of the specification.

C. Fabrication shall be done in compliance with all applicable ASTM standards or equivalent international standards.

1.7 WARRANTY

A. Fine bubble diffusers shall be warranted against defects in material and workmanship for a period of 60 months from date of Substantial Completion. All other package components shall be warranted for a minimum period of one year from Substantial Completion.

PART 2 PRODUCTS

2.1 BASIS OF DESIGN

A. Manufacturer used as the basis of design:

1. Environmental Dynamics International FlexAir ISM Membrane Disc Aeration

2. *Brad Gwinnup*
   W-Cubed Inc.
   2912 S. West Temple
   Salt Lake City, UT 84115
   bradg@wcubedinc.com

3. Alternate manufacturers may not participate in bidding as "or equals" only if pre-approved. Review as an "or equal" for pre-approval shall be in accordance with the procedures outlined in the General Conditions Article 7.05. Manufacturers listed below (as applicable) must meet or exceed this Technical Specification and related sections.

4. Pre-approved "or-equals" are as follows:

a. None

5. Manufacturers seeking to be listed as pre-approved shall provide a complete submittal for review by ENGINEER a minimum of 15 days prior to bid opening.

B. Substitution requests will not be reviewed during bidding.

2.2 GENERAL

A. The fine bubble aeration system provided in this section shall be furnished with the 304L stainless steel drop legs, PVC manifolds and air distributors, Glass Filled Polypropylene, subplates and retainer rings, Polypropylene Pipe Support for air headers and 316 stainless steel for all other supports and anchors, 316 stainless steel hardware (including anchor bolts, bolts, washers, nuts, etc.), and gaskets for aeration system flange connections, liquid purge systems, and membrane disc diffusers with integral O-ring gaskets.

2.3 MATERIALS

A. Welded Stainless Steel Components

1. Sheets and plates of Type 304L stainless steel conforming to AISI 304L and ASTM A240

2. Limit Carbon content to 0.30% maximum.

B. Non-Welded Stainless Steel Components

1. Sheets and plates of Type 304 stainless steel conforming to AISI 304 and ASTM A240

C. Fasteners and Anchorage Components

1. Type 304 stainless steel.

D. PVC Pipe and Fittings

1. Base material shall be ASTM-1784

2. Pipe shall be manufactured in accordance with ASTM D-1785 and ASTM D-2665.

2.4 SERVICE CONDITIONS

A. Elevation: 4,800 feet above mean sea level

B. Liquid Temperature: 50° F to 68° F

2.5 PERFORMANCE REQUIREMENTS

A. General: Match original diffuser design from Phase 1 project.

B. The aeration diffused aeration system shall be designed to deliver oxygen at the AOTR based on the following parameters:

1. Alpha & Fouling Factor (αF) = 0.6

2. Beta = β = 0.98

3. Theta = Θ = 1.024

4. Site Elevation = 4800 ft (AMSL)

5. Water Temperature = 10 ^{o}C (min), 15 ^{o}C (avg), 20 ^{o}C (max)

6. Initial Dissolved Oxygen into Basin = 2.0 mg/L

7. Maximum Pressure at top of drop-leg (peak conditions) = 7.98 psig

C. Aeration Basin Tank Information:

	Basin 1	Basin 2	Basin 3
Length (ft)	17.25	25.75	25.75
Width (ft)	24.25	24.25	24.25
Normal Side Water Depth (ft)	16.0	16.0	16.0
Normal Diffuser Submergence (ft)	15.2	15.2	15.2
Dissolved Oxygen Residual (mg/L)	2.0	2.0	2.0
AOTR (lbO_2/day) (Min. Day)	287	358	261
AOTR (lbO_2/day) (Avg Day)	645	784	530
AOTR (lbO_2/day) (Peak Day)	971	1036	616

D. Minimum Drop-Leg Pipe Diameter = 6”. The minimum quantity of membrane disc diffuser units in each tank shall be as follows. Additional diffusers shall be provided, as necessary, to achieve the specified performance requirements.

	Process Train No. 3
Basin 1	230
Basin 2	216
Basin 3	120
Total	566

E. Blower Operating Conditions

1. Reference Specification 43 11 33 Positive Displacement Blowers for blower design conditions.

2. The blowers are designed to operate with three duty and one standby units. In an emergency condition, all four blowers may be in operation.

2.6 DIFFUSER ELEMENTS

A. Manufacture circular membrane diffuser discs with integral O-ring of EPDM synthetic rubber compound with precision die formed slits, or equal. Thermoplastic materials (i.e. plasticized PVC or polyurethane) are not acceptable.

B. The aeration equipment vendor shall furnish diffuser elements for each zone to meet the following requirements:

1. Produce diffusers free of tears, voids, bubbles, creases, or other structural defects.

2. Furnish diffuser material to meet the following:

Item	Value/Units	ASTM
Base Polymer	EPDM	D573
UV Resistance	Carbon Black	
Specific Gravity	1.25 or less	
Durometer – Minimum	58% ± 5%	D2240
Modulus of Elasticity	500 psi	D412
Ozone Resistance (72 hrs: 40°C pphm)	No cracks @ 2X magnification	D1171 Test A
Tensile Strength	1200 psi	D412
Elongation - % - Retained 70 hrs @ 100°C - minimum at break	 75% Max 350%	 D573 D412

C. Quality Control – Test diffuser using primary sampling criteria outlined in Military Standard 105E.

D. Membrane Longevity

1. Longevity of the proposed membrane diffusers shall have been demonstrated in at least three full-scale municipal installations operating continuously for a minimum of three years.

2. Test reports, prepared by an independent testing agency, shall confirm membrane longevity through compliance with the following maximum allowed percent (+/-) change in each membrane property. Tests conducted in-house by the Supplier shall not be acceptable.

3. Data for a minimum of three diffusers from each installation shall be provided.

Property	Maximum Change
Durometer	5%
Weight	5%
Permanent Set	0.5%

E. Disc Diffuser Assembly

1. The EDI FlexAir Integral Saddle Mount (ISM) Disc diffuser assembly shall be furnished and installed.

2. Each disc diffuser assembly shall include flexible membrane, retainer ring, disc holder with mounting saddle, Click lock wedge and o-ring seal.

3. The diffuser assembly with membrane media shall be fully supported over the full diameter with a 20% glass-filled polypropylene backer plate.

4. Use of a non-fully supported diffuser membrane is not acceptable.

5. The diffuser membrane shall be held in place by a threaded retainer ring.

6. The diffuser mounting connection shall allow installation of diffusers on PVC, CPVC, ABS, or metal lateral IPS sized piping of 3-inch diameter.

7. Diffuser mounting connection shall allow installation at the manufacturer's facility or in the field.

8. Diffuser mounting connection shall allow for installation of additional diffusers, removal of diffusers, or change in location of diffusers without solvent welding in the field.

9. Mechanical Saddle attachment shall include air inlet port and positive locking mechanism to locate and lock the assembly to the air distributor piping.

10. Diffuser assemblies shall be shipped to the jobsite properly crated and protected for shipment and handling.

11. Diffuser saddle mount shall be 20% glass-filled polypropylene construction and shall be capable of withstanding an external force of 200 pounds without structural failure of the air distribution piping or diffuser assembly connection.

12. Small diameter threaded connections to attach diffusers to the air distribution header are not acceptable.

13. Saddle mount shall fully encompass the air distribution header and reinforce the pipe section at the diffuser assembly connection.

14. An O-ring gasket shall be provided to ensure an airtight seal between the mounting saddle and air header.

F. Flexible Membrane

1. Membrane material for the diffuser unit shall be EPDM rubber.

    a. Alternate membrane materials are not acceptable.

2. Membrane shall be molded in a single piece with the following characteristics.

    a. Membrane shall be 9 inch inside diameter.

    b. Perforated area on diffuser membrane shall be 0.41 square feet.

    c. Non-perforated membrane section shall be provided to seal off air distribution orifices on the diffuser support structure.

3. The diffuser unit with membrane media shall be fully capable of operating under continuous or intermittent conditions and shall be designed with check valve capabilities to prevent entry of mixed liquor into the diffuser unit or air piping on air shutdown or interruption of air supply. A minimum of three (3) integral check valve features shall be provided, not limited to the following:

    a. Membrane shall be elastic and allow openings to close when the air supply is interrupted.

    b. Membrane shall contract and shall seat on backer plate.

    c. Membrane shall employ a non-perforated section that is aligned and seals against the air distribution orifices.

    d. Use of independent or internal check valve components is not acceptable.

2.7 SYSTEM COMPONENTS

A. Drop pipe shall be provided with a flanged top connection and bottom stub end.

1. Drop pipe shall extend from the top connection to within 2 feet of the air manifold.

2. Material of construction for the drop pipe shall be schedule 5, stainless steel.

3. Drop pipe shall connect to air manifold or subheader piping by means of a wrap-around clamp adapter constructed of 304 SS with elastomeric sleeve.

4. All welds shall have local passivation as a minimum.

B. All submerged subheader distribution piping components shall be Schedule 40 PVC minimum. All air lateral piping shall be SDR 26 minimum.

1. Use of PVC piping shall only be employed when the expected mean wall temperature is less than 140°C. If temperature exceeds this limit, alternate materials shall be used or cooling loops added until the temperature is at the appropriate level.

2. Use of PVC piping shall only be employed when diffuser mounting system reinforces pipe wall at each mounting location.

3. Use of non-reinforced diffuser connections including threaded diffuser mounts is not acceptable.

4. Air piping sections shall have adjustable angle PVC positive locking flanges with stainless steel flange bolts

5. Systems employing soft couplings are not acceptable.

C. Pipe supports

1. Supports shall accommodate longitudinal movement in the piping components due to the thermal expansion and contraction over a temperature range of 100°F.

2. Supports shall be 304 stainless steel or glass filled polypropylene construction.

3. Fixed supports shall restrain the axial and rotational movement of the piping.

4. Simple supports shall allow unrestrained longitudinal movement of the in-basin piping.

5. All threaded connections shall be double-nutted.

6. Pipe straps shall be minimum 0.5 inch in width.

7. Supports shall allow leveling of the air piping with 2-inch minimum vertical adjustment at each support.

8. Pipe support spacing shall limit lateral deflection to 0.25 inch maximum.

9. Each pipe support shall be connected to basin floor by anchor bolts.

10. The integrated pipe support assembly shall be designed to withstand the associated uplift force of the piping and diffuser assemblies with a minimum design factor of safety equal to four (4).

11. Glass Filled Polypropylene (GFPP) supports shall incorporate the following features:

    a. Klik-lock™ retainer strap to secure pipe to pipe support.

    b. GFPP base to be mounted to floor with one anchor bolt.

c. Threaded base to allow bottom cradle of support to adjust in height.

d. Diameter of support base to be minimum 2.5inches (63mm) outer diameter.

D. Spare Parts:

1. The Contractor shall furnish the following spare parts and store as directed:

a. One percent of the total number of EPDM flexible membranes.

b. One set of special tools needed for installation and maintenance.

PART 3 EXECUTION

3.1 PRODUCT DELIVERY, HANDLING AND STORAGE

A. Delivery and Handling of Equipment:

1. Manufacturer and Contractor shall coordinate the delivery schedule for the project schedule.

2. Contractor shall unload and inspect all equipment and materials against reviewed shop drawings at the time of delivery. Any damage shall be reported to the freight company immediately upon receipt.

3. Equipment and materials damaged or not meeting the requirements of the reviewed shop drawings shall be immediately returned for replacement or repair.

4. Each box or shipping crate shall be properly marked to show its net weight and its contents.

B. Storage:

1. Contractor shall prepare for storage and label all equipment and materials after they have been inspected. The Contractor shall be responsible for the equipment and materials while in storage.

2. Store materials to permit easy access for inspection and identification.

3. Support all material off the ground while protecting steel members and packaged material from corrosion and deterioration as per manufacturers' instructions.

3.2 EXAMINATION

A. Verify all equipment and materials are present and meet the requirements of these Specifications.

3.3 INSTALLATION

A. Installing Contractor shall install the equipment specified herein in accordance with the Manufacturer's requirements. Vendor shall provide assistance and clarification as required during installation. Contractor responsibilities are generally as follows:

1. The Contractor will be responsible for reviewing the design of the equipment provided by the manufacturer, so that it fits properly in the structure and interfaces properly with associated equipment provided by others.

2. The Contractor will be responsible for receiving the equipment, unloading it from the common carrier, and storing it safely until it is ready to be installed.

3. The Contractor will install the manufacturer's equipment in accordance with the manufacturer's Installation, Operation and Maintenance instructions.

4. The Contractor will provide all field wiring between the electrical devices on equipment and the control panel. Contractor will also provide all required local disconnects and junction boxes.

5. The Contractor will provide all field piping, fittings, isolation valves, and related components required to connect to vendor's equipment.

B. After the equipment is installed, the vendor shall provide a factory trained, experienced, competent, and authorized representative to inspect the installation, generate a deficiency list for the Installing Contractor, and perform on-site commissioning with the assistance of the Installing Contractor.

C. Vendor's representative shall provide a minimum of two days (8 hours on-site per day minimum) of on-site installation inspection and assistance. If additional time is required to assist with the installation, it shall be at no additional cost to the Owner.

3.4 FIELD QUALITY CONTROL

A. Vendor's representative shall provide a minimum of one day (8 hours on-site per day minimum) for Initial Starting and Testing of the diffuser system. Contractor shall coordinate with the blower manufacturer for testing of the aeration system (blowers, diffusers, and related components). If additional time is required to assist with the installation, it shall be at no additional cost to the Owner.

B. Functional Field Tests required at the conclusion of installation:

1. Level Tests: Each aerobic zone shall be flooded with potable water to the tops of the diffusers. The level of the domes shall then be checked to ensure that they are at the same elevation within 0.125-inch.

2. Uniformity and Leakage Tests: Each aerobic zone shall be flooded with potable water to a depth of approximately one foot above the tops of the diffusers. Process air shall be supplied evenly to all headers in each zone. The surface of

the water above the diffusers shall then be visually inspected to ensure that air flow is uniformly distributed across the zone.

C. Field Performance Test:

1. If during full-scale operation, Owner and Engineer determine that insufficient oxygen transfer is occurring (based on vendor's oxygen transfer calculations and corresponding airflow), Owner reserves the right to declare the diffuser system defective and require vendor to conduct a field oxygen transfer test. Contractor and vendor shall prepare a testing plan for review by Owner and Engineer, and subsequently conduct the field oxygen transfer test. If the testing concludes that corrections are required, Contractor and vendor shall implement the corrections after review and approval by Owner.

3.5 COMMISSIONING EQUIPMENT

A. Perform initial testing and commissioning per Section 01 75 16.

3.6 TRAINING

A. Seller's qualified service representative shall provide a minimum of one day (8 hours on-site minimum) of training of the Buyer's staff for operation and maintenance of the equipment.

END OF SECTION

THIS PAGE WAS INTENTIONALLY LEFT BLANK

SECTION 46 66 16
ULTRAVIOLET DISINFECTION SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

A. The Contractor shall provide all labor, materials, tools, equipment, and appurtenances required to relocate the existing power distribution center (PDCs) and lamps from Channel No. 2 to Channel No. 1. The contractor shall also furnish and install new modules with lamps, new module support racks, and new low-level sensor. The UV system shall be complete and operational with all control equipment and accessories specified herein, as shown on the contract drawings. The system shall be installed by the Contractor and tested and commissioned by the manufacturer, as specified in this section.

1.2 RELATED SECTIONS

A. Division 1 – General Requirements

B. Section 01 20 00 – Measurement and Payment

C. Section 01 33 00 – Submittals Procedures

D. Section 01 40 00 – Quality Assurance and Quality Control

E. Section 01 65 00 – Commissioning of Systems

F. Section 01 73 00 – Installation, Operation, and Maintenance Manuals

G. Division 26 – Electrical

1.3 REFERENCES

A. NWRI Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (May 2012).

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Vendor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner shall be the final authority for determining the acceptability of requested deviations. The remaining

portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Submit a Bioassay Validation Report showing the UV modules have been tested in accordance with the NWRI guidelines by an accredited 3rd party engineer using full bioassay results The bioassay must demonstrate that the proposed UV system design and number of lamps will deliver the specified dose. Bioassay testing shall evaluate reactor performance over the wide range of flow rates, UV Transmittance (UVT) from 56% to 76% (measured at 254 nm, 1 cm path length) and the MS2 Reduction Equivalent Dose (RED). The bioassay testing must encompass the range of design and operating conditions described herein. Extrapolations to flow rates, UV Transmittance values, or UV doses outside the range actually tested, shall not be permitted.

D. The demonstration of Title 22 performance shall be provided showing that the system has satisfied the California Wastewater Reclamation Criteria under Title 22, Division 4 of the California Code of Regulations for unrestricted reuse (<2.2 total coli forms / 100 ml 7-day geometric mean). Documentation shall be provided verifying that the system is recognized by the California State Department of Public Health (CDPH) as being acceptable for compliance with treatment requirements of the California Recycled Water Criteria.

E. Provide detailed dosage calculations and supporting technical information for the UV disinfection system and its performance demonstrating compliance with the specified dosing requirements.

F. Submit documentation of the UV manufacturer's service capabilities, including location and experience.

G. Submit a detailed control description for operation of a single and/or multiple UV banks, including a description of all major and minor alarm scenarios, response to flow variations, units "on/off" protocol, etc.

H. Shop drawings shall include the following at a minimum:
   1. Interconnections and interface requirements, dimensions, and locations of all major elements of the UV system and critical clearance requirements.
   2. Complete description in sufficient detail to permit a thorough comparison with the appropriate Specification Section(s).
   3. Catalog information and cuts for all manufactured items, including control system components, highlighted to show actual items proposed to be provided.
   4. Schematic diagrams and electrical wiring diagrams for the overall electric power and control design of the UV system.
   5. Complete hardware fabrication and assembly specifications.
   6. Control panel layout diagrams for the panel's interior and exterior.
   7. Legend nameplate details for control panel switches, lights, and panel-mounted equipment.

8. Storage, handling, and installation instructions.
9. Requirements for any routine maintenance required prior to equipment startup.
10. Hydraulic and headloss calculations demonstrating compliance with the specified hydraulic characteristics.
11. Preliminary UV equipment O&M manuals prepared for this project.
12. Project-Specific Operation and Maintenance Manuals. Final Operation and Maintenance (O&M) manuals for this specific project shall be submitted to the Engineer upon approval of shop drawings and delivery of the equipment. The O&M manuals shall include software documentation, instructions on equipment storage, installation, startup, and operation and maintenance, together with a thorough troubleshooting guide and recommended spare parts list.

1.5 QUALITY ASSURANCE

A. The Manufacturer shall be regularly engaged in the manufacture of UV disinfection systems with a proven track record of at least fifty (50) installations of similar scope and size to the proposed system. The manufacturer shall provide experience documentation for UV disinfection systems in municipal wastewater applications.

B. The manufacturer shall be responsible for the proper design of the supplied UV disinfection system, including but not limited to, the UV banks and the corresponding power distribution units.

1.6 WARRANTY

A. The UV disinfection system shall be warranted to be free of defects in material and workmanship for a period of one (1) year from substantial completion.

B. The manufacturer shall guarantee a minimum of 12,000 hours operation time for each UV lamp under the conditions specified herein and include on/off cycles maximum of four per 24 operating hours.

C. In case of premature UV lamp failure, the manufacturer shall offer the following:
1. Lamp failure before 9,000 hours – send a replacement lamp free of charge
2. Lamp failure after 9,000 hours – issue a credit proportional to the hours not used

1.7 DESIGN AND PERFORMANCE REQUIREMENTS

A. The UV disinfection system will follow the submerged membrane bioreactor treatment system. The membranes will have a nominal pore size of 0.04 microns.

B. Design Conditions

Table 1: Design Conditions

Flow conditions:	Value
Pretreatment Method	Membrane Bioreactor
Maximum Flow (Based on Capacity of Membrane Pumps Upstream)	3.45 mgd
Average Flow (Average Day Influent Flow)	1.39 mgd
Minimum Flow	0.3 mgd
Maximum Total Suspended Solids (TSS)	<5mg/L
Design UV Transmittance (minimum) @ 253.7 nm	65%
Water Temperature	50° F to 83° F

C. Performance Requirements

1. The UV disinfection system shall deliver the Minimum UV Dose at Peak Design Flow capacity, minimum operating water temperature, and the minimum design UVT, with lamp output adjusted to account for the combined lamp degradation factor to simulate the end of lamp life condition. The end of lamp life output shall be a default of 0.5 as indicated in the table below, or higher based on a Lamp Aging Factor determined from independent testing in accordance with the NWRI Guidelines and shall be guaranteed by the manufacturer. The minimum end of lamp life output shall be calculated from the nominal lamp output, which is defined as the full power amp output after 100 hours of lamp operation. Lamp aging factor shall not exceed a maximum of 0.98.
2. The UV disinfection system fouling factor shall be a default of 0.8 as indicated in the table below, or a higher factor determined from independent testing in accordance to the NWRI guidelines and guaranteed by the manufacturer. Fouling factor shall not exceed a maximum of 0.95.
3. The effluent count shall be according to the following values:

Table 2: Treatment Requirements

Parameter	Value
Minimum UV Dose	80 mJ/cm2 and bioassay validated
Lamp Aging Factor	0.5 (default value if no independent testing in accordance with NWRI guidelines exits)
Fouling Factor	0.8 (default value if no independent testing in accordance with NWRI guidelines exits)
Effluent E. coli Count	non-detect /100 ml (7-day median) <9/100 ml (single sample maximum)

a. While the minimum UV design dose shall be 80 mJ/cm2, for flexibility, decreased energy usage, and because the Utah Administrative Code does not require a specific minimum dose, the Manufacturer shall provide a system configuration in which the lowest UV dose possible can be provided while still guaranteeing the effluent E. coli limits (noted above) are met. This dose is likely between 40 to 50 mJ/cm2.

4. Installed UV System Configuration:

a. The Contractor shall relocate the existing power distribution center (PDCs), modules, lamps, and all equipment from Bank 1, 2, and 3 from Channel No. 2 to Channel No. 1, as shown in the plans. The contractor will also furnish and install new modules per PDC, along with new lamps, new module support racks, and a new low-level sensor.

b. The system shall be installed in Channel No. 1 including, but not limited to, the following equipment:

Table 3: UV System Requirements

Parameter	Value
UV Lamp Type	High Intensity-Low Pressure
Number of Channels	2 (1 duty / 1 future)
Number of Banks in Duty Channel	3 (2 duty / 1 standby)
Number of Modules, Each Bank	8 (12 existing, 12 new)
Number of Lamps, Each Module	8 (96 existing, 96 new)
Number of Module Support Racks	3 (3 existing, 3 new)
Number of System Control Centers	1(existing)
Number of Power Distribution Centers	3(existing)
Number of Level Controller	1 (existing)
Number of Low-Level Sensor	1 (new)
Number of flow conditioning plate in Duty Channel	3 (Existing)
Maximum head loss per UV channel at peak design flow	< 8.5 inches
Maximum power consumption per channel (lamps & ballasts only)	As required per manufacturer
Maximum power consumption per channel	As required per manufacturer
Power Supply	480 volt, 3 phase, 60 hz, 4 wire plus ground

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design
   1. Trojan Technologies (Model: UV3000Plus)

B. Approved Manufacturers:
   1. Trojan Technologies
   2. Or approved equal per the Contract Documents and the Instruction to Bidders.

2.2 GENERAL

A. The open channel, gravity flow, low pressure high intensity ultraviolet (UV) amalgam lamp disinfection system shall be capable of disinfecting the specified flows based on the minimum influent water quality specified.

B. All wiring exposed to UV light shall be coated with Teflon or other UV-resistant material.

C. All material exposed to UV light shall be Type 316 stainless steel, Type 214 quartz glass, Teflon, or other suitable UV-resistant material.

D. All module welded metal components in contact with the effluent shall be Type 316L stainless steel.

E. All metal components above the effluent shall be Type 304 stainless steel with the exception of the ballast enclosure, which shall be constructed of anodized aluminum or painted sheet steel if the ballast enclosures are located above from the channel.

F. All wires connecting the lamps to the ballasts shall be enclosed inside the frame of the UV Module and not exposed to the effluent. To be considered as an alternate, wires that are exposed to the effluent shall be warranted for 15 years and will be Teflon coated to prevent degradation under constant exposure to UV light.

2.3 LAMP ARRAY CONFIGURATION

A. The lamp array configuration shall be uniform with all lamps parallel to each other and to the flow. The lamps shall be spaced per the manufacturer's standard design. Lamp array perpendicular to the flow shall not be acceptable.

B. The system shall be designed for complete immersion of the UV lamps, including both electrodes and the full length of the lamp tube, in the effluent. Both lamp electrodes shall operate at the same temperature and be cooled by the effluent.

2.4 UV LAMPS

A. The UV lamps shall be low-pressure/high-intensity amalgam. The lamps shall be preheated to promote longevity. Lamps that are not amalgam or that are based on driving a low pressure lamp at amperages greater than 500 milliamps shall not be allowed.

B. Medium pressure or other UV lamp types with a polychromatic UV output which require a higher connected electrical load than that specified to deliver the specified total UV-C (253.7 nm) output wattage shall not be acceptable.

C. The minimum UV lamp output after a 100 hour burn-in period shall be 125 watts of UV-C energy at a wavelength of 253.7 nm. Low pressure - low output or Low pressure - high intensity amalgam UV lamps with less than 125 watts UV-C output at 253.7 nm shall not be acceptable.

D. UV lamp life shall be guaranteed to 12,000 operating hours under normal operating conditions. Normal operating conditions include:

1. On/Off cycles max. 4 per 24 operating hours
2. Voltage fluctuations (230/400 V ± 10% relating to 480 V ± 10%)

E. UV lamps shall not require an extended cool down period prior to re-start should the power to the UV system fail or be interrupted for a short period of time. Systems or lamps that require long cooling periods of 10 minutes or more before re-start shall not be accepted.

F. The UV lamp output shall not fluctuate more than 5 percent due to water temperature variations between 41 to 86° F (5 to 30° C).

G. The operating skin temperature of the UV lamp shall not exceed 266° F (130° C) in order to minimize the possibility of quartz fouling.

H. The UV lamp filaments shall be the clamped design, significantly rugged to withstand shock and vibration. Each lamp base shall incorporate a dielectric barrier or pin isolator. The pin isolator shall consist of a non-conductive divider placed between the lamp pins to prevent direct arcing across the pins in moist conditions. The barrier shall be dielectrically tested for 2500 volts.

I. UV lamp minimum arc length shall be 56.3 inches (143 cm).

J. UV lamp bases shall be of a metal and ceramic construction resistant to UV and ozone.

K. UV lamps shall be rated to produce zero levels of ozone.

L. Lamps shall be operated by electronic ballasts with variable output settings.

2.5 UV LAMP ASSEMBLIES

A. Each UV lamp assembly shall consist of a UV lamp, enclosed in an individual quartz sleeve, with one end appropriately sealed by a lamp end seal comprised of an O-ring-sealed sleeve nut, which threads onto a steel cup and compresses the O-ring or open at both ends, each appropriately sealed using an O-ring sealed quartz end plug.

B. The sleeve nut shall have a knurled surface to allow a handgrip for tightening. The sleeve nut shall not require any tools for removal.

C. The closed end of the quartz sleeve shall be held in place by means of the retaining O-ring.

D. UV lamps shall be removable with the quartz sleeve and wiper system remaining in place.

E. The UV lamp quartz sleeve shall be a single piece of clear fused, Type 214 quartz circular tubing, closed at one end and the other end sealed by a lamp end seal. Lamp sleeves shall be domed at one end. The nominal wall thickness shall be 1.5 mm.

F. The sleeve shall be rated for a minimum UV transmittance of 92 percent, which shall not be subject to degradation over the life of the system.

G. All electrical connections to the lamp assembly shall be made at one end through a four pin machined, watertight plug connector.

H. The electrical connection end of the quartz sleeve shall be sealed by means of a protective retainer plug designed with dual o-rings to seal and hold the sleeves in parallel alignment. The retainers shall remain in place to protect the quartz sleeve ends against accidental damage and prevent moisture from entering the lamp module frame and the electrical connections to the other lamps in the module, without impeding the removal and replacement of the UV lamp.

I. The lamp shall be held in place by means of a molded lamp holder that shall incorporate two seals. The lamp holder will incorporate a double seal against the inside of the quartz sleeve to act in series with the external O-ring seal.

J. The two seals shall also isolate and seal the lamp from the module frame and all other lamps in the module. The quartz sleeve shall not come in contact with any steel in the frame.

K. The lamp holder shall also incorporate a UV resistant PVC molded stop that shall prevent the lamp sleeve from touching the steel cup.

2.6 UV MODULE

A. Each UV module shall consist of UV lamps with an electronic ballast enclosure mounted on a Type 316L stainless steel frame. To be considered as an alternate, ballasts housed in a separate enclosure located external to the channel shall be equipped with a suitable air conditioning system, supplied by the UV Manufacturer, to maintain internal enclosure temperatures below 80 F (26 C). No forced air ventilation shall be allowed. Ballasts housed in a separate enclosure external to the channel shall supply adequate cooling as required.

B. The ends of the lamp sleeve shall not protrude beyond the stainless steel frame of the UV Module.

C. Lamp wires shall terminate in the electronic ballast enclosure located at the top of the UV Module.

D. All lamp to ballast connections shall be made by and tested by the UV Manufacturer.

E. The electronic ballast enclosure shall contain the electronic ballasts and addressable lamp status monitoring systems.

F. Each UV Module shall be connected to a receptacle on the Power Distribution Center.

G. At the point of exit from the UV Module frame the multi-conductor cable shall pass through a waterproof strain relief.

H. Each UV Module shall have a rating of Type 6P.

I. Each UV Module shall be equipped with an interlock switch, which will automatically disconnect power to its associated UV bank if a module is raised from the UV channel or a quick disconnect plug is removed.

J. The UV Module(s) shall be designed such that operating personnel at the plant can change the lamps and quartz sleeves without requiring special tools.

K. Each UV Bank shall have at least one (1) Module-mounted, calibrated UV intensity sensor.

L. The UV modules shall be designed for submergence above the top of the UV lamps only without causing failures or damage to the system or components.

M. The UV Module support rack shall be a minimum Type 304 stainless steel and shall be mounted above the effluent level in the channel allowing adjustment to the precise height of the channel.

N. UV Modules shall include lifting lugs in order to facilitate removeable of the Modules from the Channel.

2.7 AUTOMATIC WIPING SYSTEM

A. The UV vessel(s) shall be equipped with an automatic mechanical and chemical or mechanical only wiping system with selectable wiping frequency. The mechanical wipers

must be motor or compressor or hydraulically driven and shall be operated in either manual or automatic mode.

B. The cleaning/wiping system will be fully operational while UV lamps and modules are submerged in the effluent channel and energized.

C. The wiping system shall be PLC controlled and shall be automatically initiated. Remote manual and remote auto cleaning control options shall be provided. Cleaning cycle intervals shall be field adjustable. The automatic wiping system shall be electronically controlled and/or hydraulically driven and provide a fully automatic, unattended operation.

D. The automatic wiping system shall be hydraulically powered and shall use Teflon and PTFE wipers to clean the quartz sleeves.

E. Wiping frequency shall have an adjustable number of strokes and an adjustable timer interval.

F. The wiping interval shall be adjustable from 1 to 7 times per hour. One wiping interval shall consist of two wiping cycles (one wiping cycle is defined as one wipe forward, one wipe backward). The wiping system shall be fully operational while still providing disinfection.

G. The automatic wiping system shall maintain uniform wiping tension and cleaning over complete wiping length of the quartz sleeve and the UV sensors. The cleaning system shall maintain full efficiency throughout its life, with no deterioration in quality of cleaning. Automatic wiping systems not meeting this condition shall not be accepted.

H. The wiper brush and wiper ring, or other cleaning device in contact with the quartz sleeve, shall be non-metallic and shall not damage or scratch the quartz sleeve or sensor in any way.

   1. To offset cleaning mechanism wear and to maintain positive contact and wiping efficiency with the quartz sleeve, the wiper blade ring or other cleaning device shall be self-adjusting and shall automatically adjust to account for wear over its useful life.
   2. Systems that require manual adjustments for operation or to maintain cleaning efficiency on the sleeve shall not be accepted.

I. The wiped length of the quartz sleeve shall be no less than the complete arc length.

J. The cleaning system shall be provided with the required solutions necessary for initial equipment testing and for equipment start-up

2.8 WATER LEVEL SENSOR

A. One low water level sensor shall be provided by the UV Manufacturer for Channel 1.

B. During manual, automatic and remote modes of system operation, the water level sensor shall ensure that lamps extinguish automatically if the water level in the channel drops below an acceptable level.

C. The low water level sensor shall be powered by the Power Distribution Center.

2.9 ELECTRICAL AND CONTROL SYSTEM

A. General

1. The electrical system shall be designed to provide:
    a. Maximum reliability of the UV disinfection system
    b. Segregation of plant services and supplies into sensible groups to allow for safe and simple maintenance or servicing while maintaining the required level of disinfection
    c. Plug and socket quick disconnect facilities enabling non-technical personnel to carry out lamp replacement without the need for any tools or special isolation procedures
2. Systems or designs that subject sensitive electrical or electronic components to excess humidity or poor air quality for cooling shall not be accepted.
3. Harmonic distortion correction equipment shall be provided by the manufacturer as required to meet IEEE519-1992 of The Institute of Electrical and Electronic Engineers.

B. Electronic Ballasts

1. Each UV module will consist of UV lamps with an electronic ballast enclosure mounted on a Type 316 stainless steel frame.
2. Each ballast shall drive a pair of lamps with independent control and monitoring circuits.
3. The ballast shall produce an earth free lamp power supply operating at above supply frequency and optimized to preserve lamp life.
4. The ballast shall incorporate a galvanic separation of the two circuits. In case of the secondary circuit operating in abnormal conditions regarding voltage and/or amperage, the ballast shall shut off the lamp concerned.
5. The ballast shall continue to operate without suffering damage when a short-circuit is present across the ballast output terminals.
6. The ballast shall incorporate a filament pre-heat circuit to minimize lamp failure on startup.
7. The operating power factor for the ballasts shall be above 0.98 leading or lagging.

E. Instrumentation and Control Strategy

1. Local monitoring and control shall be configured to each control unit with a local control selector (local-off-remote), power on display, status of each lamp, low UV intensity alarm, and lamp hours run counter.

2. Remote monitoring and control shall be configured to each control unit to accept the indicated inputs when remote control is selected and to provide the indicated outputs at all times with an external, supervisory control system.
    a. Inputs: On/Off for unit power, flow rate from UV effluent flow meter, influent flow valve position.
    b. Discrete Outputs (isolated contact): Power on display, chamber/cabinet, UV intensity, lamp failure alarm
    c. Analog Output (4-20 mA or digital): UV intensity signal

F. Safety Alarms

1. Minor alarms shall be provided by the PLC to indicate to plant operators that maintenance attention is required. Minor alarms shall include:
    a. "Individual Lamp Failure" shall indicate single lamp failures that occur that are not adjacent to each other.
    b. "Low Warning UV Intensity" shall be pre-set at the factory to 45 percent of the intensity after 100 hours. Alarm set point shall be field adjustable.
    c. "Flow Meter Failure" shall indicate a failure to receive a signal from the effluent flow meter (by others).
2. Major alarms shall be provided by the PLC to indicate an extreme alarm condition in which the disinfection performance may be jeopardized. Major alarms shall include:
    a. "Low-Low UV Intensity" shall be pre-set at the factory for 25 percent of the intensity after 100 hours. The alarm set point shall be field adjustable. A low intensity alarm shall not cause any bank to turn off.
    b. "Multiple Lamp Failure" shall indicate the failure of more than a pre-set 5 percent of lamps in a vessel. This pre-set percentage shall be field adjustable.
    c. "Influent Valve Closed" shall indicate the influent flow valve (by others) position is closed.
    d. "PLC Power Failure" shall indicate loss of power to the PLC.

PART 3 EXECUTION

3.1 INSTALLATION

A. All installation of the UV equipment shall be performed by the Contractor. All required installation hardware (such as, but not limited to, support braces and saddles, bolts, washers, nuts, and jam nuts) shall be furnished by the Contractor.

B. All equipment shall be installed in accordance with the UV Manufacturer'swritten installation instructions and approved shop drawings.

C. All components shall be fully tested and verified for service by the Manufacturer or an authorized representative.

3.2 STARTUP AND FIELD SERVICES

A. Provide under provisions of Section 01 40 00 and 01 65 00.

1. After the equipment is installed, the supplier shall provide a factory trained, experienced, competent, and authorized field service technician or startup engineer to the jobsite to inspect, check, and approve the equipment installation. Provide field service technician for a minimum of five 8-hour days to inspect installation, witness testing, and train Owner's personnel following startup.
2. The field technician shall furnish to the Owner, through the Engineer, a written report certifying that the equipment has been properly installed and has been operated under full load conditions and that it operated satisfactorily.
3. The local Manufacturer's representative shall not be acceptable to perform startup and field services unless specifically authorized by the Manufacturer.

3.3 SPARE PARTS, MAINTENANCE, AND SERVICE

A. Manufacturer shall provide on-site services for all maintenance and servicing of the equipment for a period of one-year from the date of project substantial completion.

C. The Manufacturer shall provide one (1) hard copy of operation and maintenance manuals and one (1) electronic copy.

END OF SECTION

THIS PAGE INTENTIONALLY LEFT BLANK