



NAMPA

City of Nampa
**Wastewater Treatment Plant
Phase I Upgrades:
Group A—Liquid Stream
Upgrades**

Volume 3—Specifications
(Division 26 through Division 44)

CH2MHILL[®]

December 2014

WBG031014203505BOI

CONTRACT DOCUMENTS

CITY OF NAMPA

NAMPA, IDAHO

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

VOLUME 3
DIVISION 26 THROUGH DIVISION 44

for the construction of the

Nampa WWTP Phase I Upgrades:
Group A—Liquid Stream Upgrades

Contract No. _____

CH2M HILL

Boise, Idaho

December 2014

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Geotechnical Engineering Evaluation, Nampa WWTP, Nampa, Idaho,
September 8, 2014

Geotechnical Engineering Evaluation, Proposed Primary Clarifier No. 3,
Nampa WWTP, Nampa, Idaho, December 6, 2005

Geotechnical Engineering Evaluation, Proposed Clarifier and RAS Pump
Station, Nampa WWTP, Nampa, Idaho, May 18, 2004

Selected Nampa WWTP Record Drawings for Facilities to be Demolished

Drainage Report, Nampa WWTP, Nampa, Idaho, December 2014

END OF SECTION

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
 2. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. Z535.4, Product Safety Signs and Labels.
 3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 4. Underwriters Laboratories, Inc. (UL).

1.03 ELECTRIC SERVICE DIVISION OF RESPONSIBILITY

- A. Incoming underground electrical service facilities provided by the serving utility as part of its normal obligation to customers is work provided outside this Contract. Under this Contract provide customer required service provisions and electrical work including, but not limited to, transformer pad site preparation, metering components and associated conduit, and secondary facilities. Schedule and coordinate work of serving utility as required to provide electric service to the Work.

1.04 SUBMITTALS

- A. Action Submittals: Provide manufacturers' data for the following:
1. Electrical service components.
 2. Nameplates, signs, and labels.

1.05 QUALITY ASSURANCE

- A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed

by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

- B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark or label.
- C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.06 ENVIRONMENTAL CONDITIONS

- A. See Area Classification and Material Selection Table on Drawings for environmental conditions, hazardous area classification needed to determine material selection, and electrical construction requirements.

PART 2 PRODUCTS

2.01 GENERAL

- A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.
- B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 to 104 degrees F.
- C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.

2.02 EQUIPMENT FINISH

- A. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with Section 09 90 00, Painting and Coating.

2.03 NAMEPLATES

- A. Material: Laminated plastic.
- B. Attachment Screws: Stainless steel.
- C. Color: Black, engraved to a white core.

D. Letter Height:

1. Pushbuttons/Selector Switches: 3/16 inch.
2. Other electrical equipment: 1/4 inch.

2.04 SIGNS AND LABELS

- A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 GENERAL

- A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.
- B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.
- C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.
- D. Keep openings in boxes and equipment closed during construction.
- E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

3.02 ANCHORING AND MOUNTING

- A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for seismic zone criteria given in Section 01 61 00, Common Product Requirements.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

- A. Drawings indicate the conduit and cabling to be included in each circuit for each piece of equipment. Do not combine power or control circuits into common raceways without authorization of Engineer.

- B. Lighting and receptacle circuits shown on Drawings correspond with the assigned circuit in the Panel Schedules. Lighting and receptacle circuits can be combined into common raceways in accordance with the requirements of the National Electrical Code.
- C. Do not combine either power circuits or control circuits without authorization of Engineer. The following wiring combinations shall not be run in the same conduit:
 - 1. Power and Discrete Control Circuits.
 - 2. Power and Analog Signal Circuits.
 - 3. Discrete Control and Analog Signal Circuits.

3.04 NAMEPLATES, SIGNS, AND LABELS

- A. Arc Flash Protection Warning Signs: Field mark motor control centers and panelboards to warn qualified persons of potential arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment. Arc Flash Protection Warning signs shall be provided in accordance with Section 26 05 70, Electrical Systems Analysis.
- B. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying the Primary Effluent Pump Station Electrical Building, and the area served by each.
- C. Equipment Nameplates:
 - 1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
 - 2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
 - 3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.
 - 4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.
- D. Procedural Signs:
 - 1. Main-Tie-Main.
 - 2. Key Interlock.

3.05 LOAD BALANCE

- A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.
- B. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.
- C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 CLEANING AND TOUCHUP PAINTING

- A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.
- B. Touchup Paint:
 - 1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
 - 2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

3.07 PROTECTION FOLLOWING INSTALLATION

- A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.
- B. When equipment intended for indoor installation is installed at Contractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

END OF SECTION

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
 - c. E814, Method of Fire Tests of Through-Penetration Fire Stops.
2. Canadian Standards Association (CSA).
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. AB 1, Molded Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
 - c. C12.1 Code for Electricity Metering
 - d. C12.6 Phase-Shifting Devices Used in Metering, Marking and Arrangement of, Terminals for
 - e. CP 1, Shunt Capacitors.
 - f. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - g. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
 - h. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories Inc. (UL):
 - a. 98, Standard for Enclosed and Dead-Front Switches.
 - b. 248, Standard for Low Voltage Fuses.
 - c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.

- d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
- e. 508, Standard for Industrial Control Equipment.
- f. 810, Standard for Capacitors.
- g. 943, Standard for Ground-Fault Circuit-Interrupters.
- h. 1059, Standard for Terminal Blocks.
- i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals: Provide manufacturers' data for the following:

1. Control devices.
2. Control relays.
3. Circuit breakers.
4. Nonfused switches.
5. Magnetic contactors.
6. Intrinsic safety barriers.
7. Firestopping.
8. Enclosures: Include enclosure data for products having enclosures.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15 to 800 amps.
3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
4. Suitable for mounting and operating in any position.
5. NEMA AB 1 and UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in OPEN position.

4. ON/OFF and TRIPPED indicating positions of operating handle.
 5. Operating handle to assume a CENTER position when tripped.
- C. Trip Mechanism:
1. Individual permanent thermal and magnetic trip elements in each pole.
 2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
 3. Two- and three-pole, common trip.
 4. Automatically opens all poles when overcurrent occurs on one pole.
 5. Test button on cover.
 6. Calibrated for 40 degrees C ambient, unless shown otherwise.
- D. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown. Do not combine power or control circuits without authorization of Engineer.
- E. Short Circuit Interrupting Ratings: Equal to rating of existing equipment, unless otherwise shown.
- F. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
1. Ground fault sensor shall be rated same as circuit breaker.
 2. Push-to-test button.
- G. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).
- H. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.
- I. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.
- J. Connections:
1. Supply (line side) at either end.
 2. Mechanical wire lugs, except crimp compression lugs where shown.

3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.
5. Use bolted bus connections, except where bolt-on is not compatible with existing breaker provisions.

K. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. NEMA KS 1.
- B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.
- D. Enclosures: See Article Enclosures.
- E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 FUSE, 250-VOLT AND 600-VOLT

- A. Power Distribution, General:
 1. Current-limiting, with 200,000 ampere rms interrupting rating.
 2. Provide to fit mountings specified with switches.
 3. UL 248.
- B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:
 1. Class: RK-1.
 2. Type: Dual element, with time delay.
 3. Manufacturers and Products:
 - a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
 - b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).

C. Cable Limiters:

1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
2. Manufacturer and Product: Bussmann; K Series.

D. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
 - a. Bussmann.
 - b. Littlefuse, Inc.

2.04 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Light: Push-to-test, LED type.

D. Pushbutton Color:

1. ON or START: Black.
2. OFF or STOP: Red.

E. Pushbutton and selector switch lockable in OFF position where indicated.

F. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.
3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
4. Letter Height: 7/64-inch.

G. Manufacturers and Products:

1. Heavy-Duty, Oil-Tight Type:
 - a. General Electric Co.; Type CR 104P.
 - b. Square D Co.; Type T.
 - c. Eaton/Cutler-Hammer; Type 10250T.

2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
 - a. Square D Co.; Type SK.
 - b. General Electric Co.; Type CR 104P.
 - c. Eaton/Cutler-Hammer; Type E34.
 - d. Crouse-Hinds; Type NCS.

2.05 TERMINAL BLOCK, 600 VOLTS

- A. UL 486E and UL 1059.
- B. Size components to allow insertion of necessary wire sizes.
- C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.
- D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.
- E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.
- F. Yoke shall guide all strands of wire into terminal.
- G. Current bar shall ensure vibration-proof connection.
- H. Terminals:
 1. Capable of wire connections without special preparation other than stripping.
 2. Capable of jumper installation with no loss of terminal or rail space.
 3. Individual, rail mounted.
- I. Marking system, allowing use of preprinted or field-marked tags.
- J. Manufacturers:
 1. Phoenix Contact.
 2. Weidmuller, Inc.
 3. Ideal.
 4. Electrovert USA Corp.

2.06 MAGNETIC CONTROL RELAY

- A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.
- B. Voltage Rating: 300 volts ac.

C. Accessories:

1. Push-to-test button.
2. Relay Status LED.

D. Manufacturers and Product:

1. Eaton/Cutler-Hammer; Type D3PF.
2. General Electric Co.

2.07 TIME DELAY RELAY

A. Industrial relay with contacts rated 8 amps continuous, 2,000VA make or break.

B. NEMA ICS 2 Designation: B150 (150 volts).

C. Solid-state electronic, field convertible ON/OFF delay.

D. One normally open and one normally closed contact (minimum).

E. Repeat accuracy plus or minus 2 percent.

F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

G. Manufacturers and Products:

1. Square D Co.; Type F.
2. Eaton/Cutler-Hammer; Type TR.
3. General Electric Co.

2.08 ELAPSED TIME METER

A. Drive: Synchronous motor.

B. Range: 0 to 99,999.9 hours, nonreset type.

C. Mounting: Semiflush panel.

D. Manufacturers and Products:

1. General Electric Co.; Type 240, 2-1/2-inch Big Look.
2. Eagle Signal Controls; Bulletin 705.

2.09 MAGNETIC LIGHTING CONTACTOR

- A. Comply with NEMA ICS 2; provide UL 508 listing.
- B. Electrically operated by dual-acting, single coil mechanism.
- C. Inherently interlocked and electrically held in CLOSED position.
- D. Main Contacts:
 - 1. Double-break, continuous-duty, rated 30 amperes, 600 volts, withstand rating of 14,000 amps rms symmetrical at 480 volts.
 - 2. Marked for electric discharge lamps, tungsten, and general purpose loads.
 - 3. Position not dependent on gravity, hooks, latches, or semipermanent magnets.
 - 4. Capable of operating in any position.
 - 5. Visual indication for each contact.
- E. Auxiliary contact relay for two-wire control.
- F. One normally open and one normally closed auxiliary contact rated 10 amperes continuous, 7,200VA make, 720VA break with NEMA designation of A600 (600 volts).
- G. Fully rated neutral terminal.
- H. Provision for remote pilot lamp with use of auxiliary contacts.
- I. Clamp type, self-rising terminal plates for solderless connections.
- J. Enclosures: See Article Enclosures.
- K. Manufacturers and Products:
 - 1. ASCO.
 - 2. Eaton/Cutler-Hammer; Class A202.
 - 3. General Electric Co.; Class 360 (electrically held).
 - 4. Square D; Class 8903, Type L (electrically held).

2.10 SUPPORT AND FRAMING CHANNELS

- A. Carbon Steel Framing Channel:
 - 1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.
 - 2. Finish: Hot-dip galvanized after fabrication.

- B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.
- C. PVC Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.
- D. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12-gauge minimum.
- E. Extruded Aluminum Framing Channel:
 - 1. Material: Extruded from Type 6063-T6 aluminum alloy.
 - 2. Fittings fabricated from Alloy 5052-H32.
- F. Manufacturers:
 - 1. B-Line Systems, Inc.
 - 2. Unistrut Corp.
 - 3. Aickinstrut.

2.11 SWITCHBOARD MATTING

- A. Provide matting having a breakdown of 20 kV minimum.
- B. Manufacturer: U.S. Mat and Rubber Company.

2.12 ENCLOSURES

- A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electro deposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.
- B. Color: Manufacturer's standard color (gray) baked-on enamel, unless otherwise shown.
- C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.
- D. Enclosure Selections: Except as shown otherwise, provide electrical enclosures according to the Area Classification and Material Selection Table on Drawings. This table provides enclosure requirements regarding NEMA 250 type and material.

PART 3 EXECUTION

3.01 GENERAL

- A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

- A. Unless otherwise shown, install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.
- B. Unless otherwise shown, install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas.

3.03 SUPPORT AND FRAMING CHANNEL

- A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.
- B. Channel Type: See Area Classification and Material Selection Table on Drawings for framing channel material requirements for each area in the Project.
- C. Paint cut ends prior to installation with the following:
 - 1. Carbon Steel Channel: Zinc-rich primer.
 - 2. PVC-Coated Channel: PVC patch.

3.04 SWITCHBOARD MATTING

- A. Install 36-inch width at switchboard and motor control centers.
- B. Matting shall run full length of all sides of equipment that have operator controls or afford access to devices.

END OF SECTION

**SECTION 26 05 05
CONDUCTORS****PART 1 GENERAL**

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
2. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. B3, Standard Specification for Soft or Annealed Copper Wire.
 - c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
 - b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
4. Insulated Cable Engineer's Association, Inc. (ICEA):
 - a. S-58-679, Standard for Control Cable Conductor Identification.
 - b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
 - c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
5. National Electrical Manufacturers' Association (NEMA):
 - a. CC 1, Electric Power Connectors for Substations.
 - b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
 - c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.

- e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
- 6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- 7. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
- 8. Underwriters Laboratories Inc. (UL):
 - a. 13, Standard for Safety for Power-Limited Circuit Cables.
 - b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
 - c. 62, Standard for Safety for Flexible Cord and Cables.
 - d. 486A-486B, Standard for Safety for Wire Connectors.
 - e. 486C, Standard for Safety for Splicing Wire Connectors.
 - f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - g. 854, Standard for Safety for Service-Entrance Cables.
 - h. 1072, Standard for Safety for Medium-Voltage Power Cables.
 - i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - j. 1569, Standard for Safety for Metal-Clad Cables.
 - k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Product Data:
 - a. Wire and cable.
 - b. Wire and cable accessories.
- 2. Manufactured Wire Systems:
 - a. Product data.
 - b. Rating information.
 - c. Dimensional drawings.
 - d. Special fittings.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

- 1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

- A. Conform to applicable requirements of NEMA WC 70.
- B. Conductor Type:
 1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
 2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
 3. All Other Circuits: Stranded copper.
- C. Insulation: Type XHHW-2.

2.02 600-VOLT RATED CABLE

- A. General:
 1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
 2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
 3. Suitable for installation in open air, in cable trays, or conduit.
 4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
 5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.
- B. Type 1, Multiconductor Control Cable:
 1. Conductors:
 - a. 14 AWG, seven-strand copper.
 - b. Insulation: 15-mil PVC with 4-mil nylon.
 - c. UL 1581 listed as Type THHN/THWN rated VW-1.
 - d. Conductor group bound with spiral wrap of barrier tape.
 - e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
 2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.

3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:

- a. Okonite Co.
- b. Southwire.

C. Type 2, Multiconductor Power Cable:

1. General:

- a. Meet or exceed UL 1581 for cable tray use.
- b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
- c. Overall Jacket: PVC.

2. Conductors:

- a. Class B stranded, coated copper.
- b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
- c. UL rated VW-1 or listed Type XHHW-2.
- d. Color Code:
 - 1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
 - 2) Conductors, size 6 AWG and larger, ICEA S-73-532, Method 4.

3. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.

4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2	0.42	45
		3	0.45	
		4	0.49	

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
10	10	2	0.54	60
		3	0.58	
		4	0.63	
8	10	3	0.66	60
		4	0.75	
6	8	3	0.74	60
		4	0.88	
4	6	3	0.88	60
		4	1.04	
2	6	3	1.01	80
		4	1.16	
1	6	3	1.10	80
		4	1.25	
1/0	6	3	1.22	80
		4	1.35	
2/0	4	3	1.32	80
		4	1.53	
3/0	4	3	1.40	80
		4	1.60	
4/0	4	3	1.56	80
		4	1.78	

5. Manufacturers:

- a. Okonite Co.
- b. Southwire.

D. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.

- b. 20 AWG, seven-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nominal nylon.
 - e. Color Code: Pair conductors, black and red.
5. Manufacturers:
- a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.
- E. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.
- 1. Outer Jacket: 45-mil nominal.
 - 2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
 - 3. Dimension: 0.32-inch nominal OD.
 - 4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand, tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nylon.
 - e. Color Code: Triad conductors black, red, and blue.
 - 5. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.

2.03 SPECIAL CABLES

- A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:
- 1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
 - 2. Suitable for high speed network applications including gigabit Ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
 - 3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
 - 4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.

5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
6. Manufacturer and Product: Belden; 7852A.

2.04 GROUNDING CONDUCTORS

- A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE insulation.
- B. Direct Buried: Bare stranded copper.

2.05 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

- A. Tape:
 1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
 2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
 3. Arc and Fireproofing:
 - a. 30-mil, elastomer.
 - b. Manufacturers and Products:
 - 1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
 - 2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.
- B. Identification Devices:
 1. Sleeve:
 - a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
 - b. Manufacturers and Products:
 - 1) Raychem; Type D-SCE or ZH-SCE.
 - 2) Brady, Type 3PS.
 2. Heat Bond Marker:
 - a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
 - b. Self-laminating protective shield over text.
 - c. Machine printed black text.
 - d. Manufacturer and Product: 3M Co.; Type SCS-HB.
 3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.

4. Tie-On Cable Marker Tags:
 - a. Chemical-resistant white tag.
 - b. Size: 1/2 inch by 2 inches.
 - c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulug.
 - 3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Seamless.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulink.
 - 3) ILSCO; ILSCONS.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
 - a. UL 486C.
 - b. Plated steel, square wire springs.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts.
 - 2) Ideal; Twister.
4. Self-Insulated, Set Screw Wire Connector:
 - a. Two piece compression type with set screw in brass barrel.
 - b. Insulated by insulator cap screwed over brass barrel.
 - c. Manufacturers:
 - 1) 3M Co.
 - 2) Thomas & Betts.
 - 3) Marrette.

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

- b. Manufacturers and Products:
 - 1) Thomas & Betts; Color-Keyed.
 - 2) Burndy; Hydent.
 - 3) ILSCO.
 - 4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Locktite.
 - 2) Burndy; Quiklug.
 - 3) ILSCO.
- E. Cable Ties:
- 1. Nylon, adjustable, self-locking, and reusable.
 - 2. Manufacturer and Product: Thomas & Betts; TY-RAP.
- F. Heat Shrinkable Insulation:
- 1. Thermally stabilized cross-linked polyolefin.
 - 2. Single wall for insulation and strain relief.
 - 3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
 - 4. Manufacturers and Products:
 - a. Thomas & Betts; SHRINK-KON.
 - b. Raychem; RNF-100 and ES-2000.

2.06 PULLING COMPOUND

- A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.
- B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
- C. Approved for intended use by cable manufacturer.
- D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
- E. Manufacturers:
 - 1. Ideal Co.
 - 2. Polywater, Inc.
 - 3. Cable Grip Co.

2.07 SOURCE QUALITY CONTROL

- A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

PART 3 EXECUTION

3.01 GENERAL

- A. Conductor installation shall be in accordance with manufacturer's recommendations.
- B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.
- C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
- D. Terminate conductors and cables, unless otherwise indicated.
- E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.
- F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.
- G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.
- H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.
- I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

3.02 POWER CONDUCTOR COLOR CODING

- A. Conductors 600 Volts and Below:
 - 1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
 - 2. 8 AWG and Smaller: Provide colored conductors.

3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
Note: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

3.03 CIRCUIT IDENTIFICATION

- A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.
- C. Circuits Not Appearing in Circuit Schedules:
 - 1. Assign circuit name based on device or equipment at load end of circuit.
 - 2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:

1. Conductors 10 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 8 AWG and Larger:
 - a. Identify with marker plates or tie-on cable marker tags.
 - b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

- A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.
- B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.
- C. Connections and Terminations:
 1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
 2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
 3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
 4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
 5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
 6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
 7. Place no more than one conductor in any single-barrel pressure connection.
 8. Install crimp connectors with tools approved by connector manufacturer.
 9. Install terminals and connectors acceptable for type of material used.
 10. Compression Lugs:
 - a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
 - b. Do not use plier type crimpers.

- D. Do not use soldered mechanical joints.
- E. Splices and Terminations:
 - 1. Insulate uninsulated connections.
 - 2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
 - 3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
 - 4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.
- F. Cap spare conductors with UL listed end caps.
- G. Cabinets, Panels, and Motor Control Centers:
 - 1. Remove surplus wire, bridle and secure.
 - 2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.
- H. Control and Instrumentation Wiring:
 - 1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
 - 2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
 - 3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
 - 4. Where connections of cables installed under this section are to be made under Section 40 90 00, Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
 - 5. Cable Protection:
 - a. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
 - b. Maintain integrity of shielding of instrumentation cables.
 - c. Ensure grounds do not occur because of damage to jacket over shield.
- I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
2. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC).

1.02 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND ROD

- A. Material: Copper-clad.
- B. Diameter: Minimum 1/2 inch.
- C. Length: 8 feet.

2.02 GROUND CONDUCTORS

- A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Utilize low-smoke, low-emission process.
3. Manufacturers:
 - a. Erico Products, Inc.; Cadweld and Cadweld Exolon.
 - b. Thermoweld.

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:
 - a. Burndy Corp.; Hyground Irreversible Compression.
 - b. Thomas and Betts Co.
 - c. ILSCO.

2.04 GROUNDING WELLS

A. Ground rod box complete with cast iron riser ring and traffic cover marked GROUND ROD.

B. Manufacturers and Products:

1. Christy Co.; No. G5.
2. Lightning and Grounding Systems, Inc.; I-R Series.

PART 3 EXECUTION

3.01 GENERAL

- A. Grounding shall be in compliance with NFPA 70 and IEEE C2.
- B. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.
- C. Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.
- D. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.

- E. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.
- F. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.
- G. Shielded Instrumentation Cables:
 - 1. Ground shield to ground bus at power supply for analog signal.
 - 2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
 - 3. Do not ground instrumentation cable shield at more than one point.

3.02 WIRE CONNECTIONS

- A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.
- B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.
- C. Connect ground conductors to raceway grounding bushings.
- D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.
- E. Connect enclosure of equipment containing ground bus to that bus.
- F. Bolt connections to equipment ground bus.
- G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.
- H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.
- I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.03 MOTOR GROUNDING

- A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.
- B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.
- C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box; if none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.
- D. Motors 10 hp and Above: Use furnished ground lug in motor connection box; if none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.
- E. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

- A. Install full length with conductor connection at upper end.
- B. Install with connection point below finished grade, unless otherwise shown.
- C. Space multiple ground rods by one rod length.

3.05 GROUNDING WELLS

- A. Install for ground rods located inside buildings, asphalt and paved areas.
- B. Install riser ring and cover flush with surface.
- C. Place 6 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

- A. General:
 - 1. Abovegrade Connections: Install exothermic weld or compression-type connectors.
 - 2. Belowgrade Connections: Install exothermic weld or compression type connectors.
 - 3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
 - 4. Notify Owner prior to backfilling ground connections.

- B. Exothermic Weld Type:
 - 1. Wire brush or file contact point to bare metal surface.
 - 2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
 - 3. Avoid using badly worn molds.
 - 4. Mold to be completely filled with metal when making welds.
 - 5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

- C. Compression Type:
 - 1. Install in accordance with connector manufacturer's recommendations.
 - 2. Install connectors of proper size for grounding conductors and ground rods specified.
 - 3. Install using connector manufacturer's compression tool having proper sized dies and operate per manufacturer's instructions.

3.07 METAL STRUCTURE GROUNDING

- A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.
- B. Bond electrical equipment supported by metal platforms to the platforms.
- C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.08 MANHOLE AND HANDHOLE GROUNDING

- A. Install one ground rod inside each.
- B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.
- C. Make connections of grounding conductors fully visible and accessible.
- D. Connect all noncurrent-carrying metal parts, and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.09 SURGE PROTECTION EQUIPMENT GROUNDING

- A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
 2. ASTM International (ASTM):
 - a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
 - b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 3. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
 4. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
 5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. C80.1, Electrical Rigid Steel Conduit (ERSC).
 - c. C80.3, Steel Electrical Metallic Tubing (EMT).
 - d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
 - e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
 - f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
 - h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
 - j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - k. VE 1, Metallic Cable Tray Systems.

6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories Inc. (UL):
 - a. 1, Standard for Safety for Flexible Metal Conduit.
 - b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
 - c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
 - d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
 - e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
 - f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
 - g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
 - h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
 - i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
 - j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
 - k. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
 - l. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
 - m. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - n. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's Literature:
 - a. Rigid galvanized steel conduit.
 - b. Intermediate metal conduit.
 - c. PVC Schedule 40 conduit.
 - d. PVC tubing (Type EB) conduit.
 - e. PVC-coated rigid galvanized steel conduit, submittal to include copy of manufacturer's warranty.
 - f. Flexible metal, liquid-tight conduit.
 - g. Flexible metal, nonliquid-tight conduit.
 - h. Innerduct.
 - i. Junction and pull boxes used at or below grade.
 - j. Large junction and pull boxes.
 - k. Terminal junction boxes.

2. Precast Handholes:
 - a. Dimensional drawings and descriptive literature.
 - b. Traffic loading calculations.
 - c. Accessory information.
- B. Informational Submittals: Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

- A. Authority Having Jurisdiction (AHJ):
 1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.
- B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

- A. Rigid Galvanized Steel Conduit (RGS):
 1. Meet requirements of NEMA C80.1 and UL 6.
 2. Material: Hot-dip galvanized with chromated protective layer.
- B. Intermediate Metal Conduit (IMC):
 1. Meet requirements of NEMA C80.6 and UL 1242.
 2. Material: Hot-dip galvanized with chromated and lacquered protective layer.
- C. PVC Schedule 40 Conduit:
 1. Meet requirements of NEMA TC 2 and UL 651.
 2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

- D. PVC Tubing (Type EB):
1. Meet requirements of NEMA TC 6 and UL 651A.
 2. UL listed for reinforced concrete encasement and 90 degrees C insulated conductors.
- E. PVC-Coated Rigid Galvanized Steel Conduit:
1. Meet requirements of NEMA RN 1.
 2. Material:
 - a. Meet requirements of NEMA C80.1 and UL 6.
 - b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
 - c. Interior finish: Urethane coating, 2-mil nominal thickness.
 3. Threads: Hot-dipped galvanized and factory coated with urethane.
 4. Bendable without damage to interior or exterior coating.
- F. Flexible Metal, Liquid-Tight Conduit:
1. UL 360 listed for 105 degrees C insulated conductors.
 2. Material: Galvanized steel with extruded PVC jacket.
- G. Flexible Metal, Nonliquid-Tight Conduit:
1. Meet requirements of UL 1.
 2. Material: Galvanized steel.
- H. Innerduct: See Section 40 95 80, Fiber Optic Communication System.

2.02 FITTINGS

- A. Rigid Galvanized Steel and Intermediate Metal Conduit:
1. General:
 - a. Meet requirements of UL 514B.
 - b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
 2. Bushing:
 - a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
 - b. Manufacturers and Products:
 - 1) Appleton; Series BU-I.
 - 2) O-Z/Gedney; Type HB.
 3. Grounding Bushing:
 - a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.

- b. Manufacturers and Products:
 - 1) Appleton; Series GIB.
 - 2) O-Z/Gedney; Type HBLG.
4. Conduit Hub:
 - a. Material: Malleable iron with insulated throat with bonding screw.
 - b. UL listed for use in wet locations.
 - c. Manufacturers and Products:
 - 1) Appleton, Series HUB-B.
 - 2) O-Z/Gedney; Series CH.
 - 3) Meyers; ST Series.
5. Conduit Bodies:
 - a. Sized as required by NFPA 70.
 - b. Manufacturers and Products (For Normal Conditions):
 - 1) Appleton; Form 35 threaded unilets.
 - 2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
 - 3) Killark; Series O electrolets.
 - 4) Thomas & Betts; Form 7 or Form 8.
 - c. Manufacturers (For Hazardous Locations):
 - 1) Appleton.
 - 2) Crouse-Hinds.
 - 3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
 - a. Concrete tight, hot-dip galvanized malleable iron.
 - b. Manufacturers and Products:
 - 1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
 - 2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYF, EYM, or ESU.
 - 2) Crouse-Hinds; Type EYS or EZS.
 - 3) Killark; Type EY or Type EYS.
9. Drain Seal:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYD.
 - 2) Crouse-Hinds; Type EYD or Type EZD.
10. Drain/Breather Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type ECDB.
 - 2) Crouse-Hinds; ECD.

11. Expansion Fitting:
 - a. Manufacturers and Products:
 - 1) Deflection/Expansion Movement:
 - a) Appleton; Type DF.
 - b) Crouse-Hinds; Type XD.
 - 2) Expansion Movement Only:
 - a) Appleton; Type XJ.
 - b) Crouse-Hinds; Type XJ.
 - c) Thomas & Betts; XJG-TP.
 12. Cable Sealing Fitting:
 - a. To form watertight nonslip cord or cable connection to conduit.
 - b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
 - c. Manufacturers and Products:
 - 1) Appleton; CG-S.
 - 2) Crouse-Hinds; CGBS.
- B. PVC Conduit and Tubing:
1. Meet requirements of NEMA TC 3.
 2. Type: PVC, slip-on.
- C. PVC-Coated Rigid Galvanized Steel Conduit:
1. Meet requirements of UL 514B.
 2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
 3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
 4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
 5. Overlapping pressure-sealing sleeves.
 6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
 7. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.
 8. Expansion Fitting:
 - a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.
- D. Flexible Metal, Liquid-Tight Conduit:
1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
 2. Insulated throat and sealing O-rings.

3. Manufacturers and Products:
 - a. Thomas & Betts; Series 5331.
 - b. O-Z/Gedney; Series 4Q.

E. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Body: Steel.
3. Throat: Nylon insulated.
4. 1-1/4-Inch Conduit and Smaller: One screw body.
5. 1-1/2-Inch Conduit and Larger: Two screw body.
6. Manufacturer and Product: Appleton; Series 7400.

F. Watertight Entrance Seal Device:

1. New Construction:
 - a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.
2. Cored-Hole Application:
 - a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.03 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.

B. Cast Metal:

1. Box: Malleable iron or cast ferrous metal.
2. Cover: Gasketed, weatherproof, malleable iron or cast ferrous metal, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.
5. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS or Type FD.
 - b. Appleton; Type FS or Type FD.
 - c. Killark.

C. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron, cast ferrous metal, or cast aluminum.

3. Coating:
 - a. Exterior Surfaces: 40-mil PVC.
 - b. Interior Surfaces: 2-mil urethane.
4. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.

2.04 JUNCTION AND PULL BOXES

- A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.
- B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.
- C. Large Stainless Steel Box:
 1. NEMA 250 Type 4X.
 2. Box: 14-gauge, ASTM A240/A240M, Type 304 stainless steel, with white enamel painted interior mounting panel.
 3. Cover: Hinged with clamps.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.
- D. Large Steel Box:
 1. NEMA 250 Type 1 and 12.
 2. Box: 14-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by Owner.
 3. Cover: Hinged with clamps.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.
- E. Large Nonmetallic Box:
 1. NEMA 250 Type 4X.
 2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
 3. Cover: Hinged with clamps.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.

5. Conduit hubs and mounting lugs.
6. Manufacturers and Products:
 - a. Crouse-Hinds; Type NJB.
 - b. Carlon; Series N, C, or H.
 - c. Robroy Industries.

F. Concrete Box, Nontraffic Areas:

1. Box: Reinforced, cast concrete with extension.
2. Cover: Steel diamond plate with locking bolts.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Size: 10 inches by 17 inches, minimum.
5. Manufacturers and Products:
 - a. Utility Vault Co.; Series 36-1017.
 - b. Christy, Concrete Products, Inc.; N9.
 - c. Quazite; "PG" Style.

2.05 TERMINAL JUNCTION BOX

- A. Cover: Hinged, unless otherwise shown.
- B. Interior Finish: Paint with white enamel or lacquer.
- C. Terminal Blocks:
 1. Separate connection point for each conductor entering or leaving box.
 2. Spare Terminal Points: 25 percent, minimum.

2.06 METAL WIREWAYS

- A. Meet requirements of UL 870.
- B. Type: Steel-enclosed, lay-in type.
- C. Cover: Hinged with friction latch.
- D. Rating: Indoor or outdoor as required by environment.
- E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.
- F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.
- G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:

1. Circle AW.
2. Hoffman.
3. Square D.

2.07 PRECAST HANDHOLES

- A. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.
- B. Loading: AASHTO, H-20 in accordance with ASTM C857.
- C. Access: Provide cast concrete 6- or 12-inch risers and access hole adapters between top of manhole and finished grade at required elevations.
- D. Drainage:
 1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
 2. Provide drainage outlet at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.
- E. Raceway Entrances:
 1. Provide on all four sides.
 2. Provide knockout panels or precast individual raceway openings.
 3. At entrances where raceways are to be installed by others, provide minimum 12-inch-high by 24-inch-wide knockout panels for future raceway installation.
- F. Embedded Pulling Iron:
 1. Material: 3/4-inch-diameter stock, fastened to overall steel reinforcement before concrete is placed.
 2. Location:
 - a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
 - b. Floor: Centered below manhole or handhole cover.
- G. Cable Racks:
 1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.

2. Wall Attachment:
 - a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
 - b. Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
 - c. Arrange in order that spare raceway ends are clear for future cable installation.

H. Handhole Frames and Covers:

1. Material: Steel, hot-dipped galvanized.
2. Cover Type: Solid, hinged, torsion spring, of nonskid design.
3. Cover Loading: AASHTO H-20.
4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
 - a. 600 Volts and Below: ELECTRIC LV.

I. Hardware: Steel, hot-dip galvanized.

J. Furnish knockout for ground rod in each handhole.

K. Manufacturers:

1. Utility Vault Co.
2. Penn-Cast Products, Inc.
3. Concrete Conduit Co.
4. Associated Concrete Products, Inc.
5. Pipe, Inc.

2.08 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:
 - a. Nonmetallic, interlocking, for multiple conduit sizes.
 - b. Suitable for all types of conduit.
 - c. Manufacturers:
 - 1) Underground Device, Inc.
 - 2) Carlon.
2. Template Type:
 - a. Nonmetallic, custom made one-piece spacers.
 - b. Suitable for all types of conduit.
 - c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.

- d. Conduit openings cut 1 inch larger than conduit outside diameter.
- e. Additional openings for stake-down, rebar, and concrete flow through as required.
- f. Manufacturer and Product: SP Products; Quik Duct.

B. Identification Devices:

- 1. Raceway Tags:
 - a. Material: Permanent, nonferrous metal.
 - b. Shape: Round.
 - c. Raceway Designation: Pressure stamped, embossed, or engraved.
 - d. Tags relying on adhesives or taped-on markers not permitted.
- 2. Warning Tape:
 - a. Material: Polyethylene, 4-mil gauge with detectable strip.
 - b. Color: Red.
 - c. Width: Minimum 3 inches.
 - d. Designation: Warning on tape that electric circuit is located below tape.
 - e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
 - f. Manufacturers and Products:
 - 1) Panduit; Type HTDU.
 - 2) Reef Industries; Terra Tape.

C. Heat Shrinkable Tubing:

- 1. Material: Heat-shrinkable, cross-linked polyolefin.
- 2. Semi-flexible with meltable adhesive inner liner.
- 3. Color: Black.
- 4. Manufacturers:
 - a. Raychem.
 - b. 3M.

D. Wraparound Duct Band:

- 1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
- 2. Width: 50 mm minimum.
- 3. Manufacturer and Product: Raychem; Type TWDB.

PART 3 EXECUTION

3.01 GENERAL

- A. Conduit and tubing sizes shown are based on use of copper conductors. Reference Section 26 05 05, Conductors, concerning conduit sizing for aluminum conductors.
- B. Comply with NECA Installation Standards.
- C. Crushed or deformed raceways not permitted.
- D. Maintain raceway entirely free of obstructions and moisture.
- E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
- F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
- G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
- H. Group raceways installed in same area.
- I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.
- J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
- K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
- L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.
- M. Install watertight fittings in outdoor, underground, or wet locations.
- N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
- O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

- P. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.
- Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
- R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
- S. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 REUSE OF EXISTING CONDUITS

- A. Where Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.
 - 1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
 - 2. Conduit is sized per the NEC.
 - 3. Conduit is of the type specified in Contract Documents.
 - 4. Conduit is supported as specified in Contract Documents.
- B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.03 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

- A. Minimum Cover: 2 inches, including fittings.
- B. Conduit placement shall not require changes in reinforcing steel location or configuration.
- C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.
- D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Engineer.
- E. Slabs and Walls (Requires Engineer Approval):
 - 1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
 - 2. Install within middle two-fourths of slab or wall.
 - 3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.

4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.04 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch.

B. Exposed Conduit: See Area Classification and Material Selection Table, unless noted otherwise.

C. Interior, Concealed (Not Embedded in Concrete):

1. Rigid galvanized steel.
2. Intermediate metal.
3. PVC Schedule 40.

D. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.

E. Direct Earth Burial:

1. PVC Schedule 40.
2. PVC-coated rigid galvanized steel.

F. Concrete-Encased Ductbank:

1. PVC Schedule 40.
2. PVC tubing (Type EB), reinforced concrete ductbank only.

G. Under Slabs-On-Grade:

1. PVC Schedule 40.
2. PVC-coated rigid galvanized steel.

- H. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit.
- I. Under Equipment Mounting Pads: PVC Schedule 40 conduit.
- J. Exterior Light Pole Foundations: PVC Schedule 40 conduit.
- K. Corrosive Areas: PVC-coated rigid galvanized steel.
- L. Innerduct: Shall be installed by qualified contractor per Section 40 95 80, Fiber Optic Communication System.

3.05 FLEXIBLE CONNECTIONS

- A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:
 - 1. Conduit Size 4 Inches or Less: Flexible, metal liquid-tight conduit.
 - 2. Conduit Size Over 4 Inches: Nonflexible.
 - 3. Wet or Corrosive Areas: Flexible, metal liquid-tight conduit.
 - 4. Dry Areas: Flexible, metallic nonliquid-tight.
- B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.
- C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.
- D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.06 PENETRATIONS

- A. Make at right angles, unless otherwise shown.
- B. Notching or penetration of structural members, including footings and beams, not permitted.
- C. Apply heat shrinkable tubing to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.
- D. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

E. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
 - a. Provide a watertight seal.
 - b. Without Concrete Encasement: Install watertight entrance seal device on each side.
 - c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
 - d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
 - e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
3. Heating, Ventilating, and Air Conditioning Equipment:
 - a. Penetrate equipment in area established by manufacturer.
 - b. Terminate conduit with flexible metal conduit at junction box or conduit attached to exterior surface of equipment prior to penetrating equipment.
 - c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
4. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
5. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
 - a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
 - b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
6. Manholes and Handholes:
 - a. Metallic Raceways: Provide insulated grounding bushings.
 - b. Nonmetallic Raceways: Provide bell ends flush with wall.
 - c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.07 SUPPORT

- A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 10 feet in any application. Do not support from piping, pipe supports, or other raceways.
- B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 20 percent extra space for future conduit.

- C. Application/Type of Conduit Strap:
 - 1. Rigid Steel Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
 - 2. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
 - 3. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.

- D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
 - 1. Wood: Wood screws.
 - 2. Hollow Masonry Units: Toggle bolts.
 - 3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
 - 4. Steelwork: Machine screws.
 - 5. Location/Type of Hardware:
 - a. Dry, Noncorrosive Areas: Galvanized.
 - b. Wet, Noncorrosive Areas: Stainless steel.
 - c. Corrosive Areas: Stainless steel.

- E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.08 BENDS

- A. Install concealed raceways with a minimum of bends in the shortest practical distance.

- B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

- C. Install with symmetrical bends or cast metal fittings.

- D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

- E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

- F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:

1. Bends 30 Degrees and Larger: Provide factory-made elbows.
2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
3. Use manufacturer's recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.09 EXPANSION/DEFLECTION FITTINGS

- A. Provide on raceways at structural expansion joints and in long tangential runs.
- B. Provide expansion/deflection joints for 25 degrees F maximum temperature variation.
- C. Install in accordance with manufacturer's instructions.

3.10 PVC CONDUIT

A. Solvent Welding:

1. Apply manufacturer recommended solvent to joints.
2. Install in order that joint is watertight.

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.11 PVC-COATED RIGID STEEL

- A. Install in accordance with manufacturer's instructions.
- B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.
- C. Provide PVC boot to cover exposed threading.

3.12 INNERDUCT

- A. Install in accordance with manufacturer's instructions.

3.13 WIREWAYS

- A. Install in accordance with manufacturer's instructions.
- B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.
- C. Applications:
 - 1. Metal wireway in indoor dry locations.
 - 2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations

3.14 TERMINATION AT ENCLOSURES

- A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.
- B. Nonmetallic, Cabinets, and Enclosures:
 - 1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
 - 2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.
- C. Sheet Metal Boxes, Cabinets, and Enclosures:
 - 1. General:
 - a. Install insulated bushing on ends of conduit where grounding is not required.
 - b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
 - c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
 - d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
 - e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
 - 2. Rigid Galvanized or Intermediate Conduit:
 - a. Provide one lock nut each on inside and outside of enclosure.
 - b. Install grounding bushing at source enclosure.
 - c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
 - 3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
 - 4. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.

5. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, Switchboard, and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

3.15 UNDERGROUND RACEWAYS

- A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.
- B. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.
- C. Make routing changes as necessary to avoid obstructions or conflicts.
- D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.
- E. Union type fittings not permitted.
- F. Spacers:
 1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
 2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.
- G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.
- H. Transition from Underground to Exposed: PVC-coated rigid steel conduit.
- I. Installation with Other Piping Systems:
 1. Crossings: Maintain minimum 12-inch vertical separation.
 2. Parallel Runs: Maintain minimum 12-inch separation.
 3. Installation over valves or couplings not permitted.

- J. Metallic Raceway Coating: Along entire length, apply wraparound duct band with one-half tape width overlap to obtain two complete layers, or apply heat shrinkable tubing.
- K. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.
- L. Provide expansion/deflection fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.
- M. Concrete Encasement:
 - 1. As specified in Section 03 30 00, Cast-in-Place Concrete.
 - 2. Concrete Color: Red.
- N. Backfill: As specified in ISPWC. Controlled low strength fill is an acceptable bedding and pipe zone material.

3.16 UNDER SLAB RACEWAYS

- A. Make routing changes as necessary to avoid obstructions or conflicts.
- B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.
- C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.
- D. Raceway spacing, in a single layer or multiple layers:
 - 1. 3 inches clear between adjacent 2-inch or larger raceway.
 - 2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.
- E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.
- F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.
- G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.

H. Fittings:

1. Union type fittings are not permitted.
2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.17 OUTLET AND DEVICE BOXES

A. General:

1. Install plumb and level.
2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
4. Install galvanized mounting hardware in industrial areas.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
 - a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
 - a. Dimensions given to centerline of box.
 - b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
 - c. Do not straddle CMU block or other construction joints.

2. Light Switch:
 - a. 48 inches above floor.
 - b. When located next to door, install on lock side of door.
 3. Thermostat: 54 inches above floor.
 4. Telephone Outlet:
 - a. 15 inches above floor.
 - b. 6 inches above counter tops.
 - c. Wall Mounted: 52 inches above floor.
 5. Convenience Receptacle:
 - a. General Interior Areas: 15 inches above floor.
 - b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of backsplash, or 6 inches above counter tops without backsplash.
 - c. Industrial Areas: 48 inches above floor.
 - d. Outdoor Areas: 24 inches above finished grade.
 6. Special-Purpose Receptacle: 48 inches above floor or as shown.
 7. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.
- E. Flush Mounted:
1. Install with concealed conduit.
 2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
 3. Holes in surrounding surface shall be no larger than required to receive box.
- F. Supports:
1. Support boxes independently of conduit by attachment to building structure or structural member.
 2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
 3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
 4. Provide plaster rings where necessary.
 5. Boxes embedded in concrete or masonry need not be additionally supported.
- G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

- H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.18 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

C. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

D. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.

2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
 3. Obtain Owner's written acceptance prior to installation in paved areas, roadways, or walkways.
 4. Use boxes and covers suitable to support anticipated weights.
- E. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.19 HANDHOLES

- A. Excavate, shore, brace, backfill, and final grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.
- B. Do not install until final raceway grading has been determined.
- C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.
- D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.
- E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.20 EMPTY RACEWAYS

- A. Provide permanent, removable cap over each end.
- B. Provide PVC plug with pull tab for underground raceways with end bells.
- C. Provide nylon pull cord.
- D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.21 IDENTIFICATION DEVICES

- A. Raceway Tags:
 1. Identify origin and destination.
 2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
 3. Install tags at each terminus for concealed raceways.
 4. Provide noncorrosive wire for attachment.

- B. Warning Tape: Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of run.

3.22 PROTECTION OF INSTALLED WORK

- A. Protect products from effects of moisture, corrosion, and physical damage during construction.
- B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.
- C. Touch up painted conduit threads after assembly to cover nicks or scars.
- D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

SECTION 26 05 70
ELECTRICAL SYSTEMS ANALYSIS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American National Standards Institute (ANSI).
 2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - b. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
 - c. 399, Recommended Practice for Industrial and Commercial Power System Analysis.
 - d. 1584, Guide for Performing Arc Flash Hazard Calculations.
 3. National Electrical Manufacturers Association (NEMA): Z535.4, Product Safety Signs and Labels.
 4. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 70E, Standard for Electrical Safety in the Workplace.
 5. Occupational Safety and Health Standards (OSHA): 29 CFR, Part 1910 Subpart S, Electrical.

1.02 SUBMITTALS

- A. Action Submittals:
1. Short circuit study.
 2. Protective Device Coordination Study: Submit within 90 days after approval of short circuit study.
 3. Arc flash study.
 4. Arc flash warning labels.

1.03 QUALITY ASSURANCE

- A. Short circuit and protective device coordination and arc flash studies shall be prepared by manufacturer furnishing switchboard, and MCC equipment for incoming service or a professional electrical engineer registered in the State of Idaho.

1.04 SEQUENCING AND SCHEDULING

- A. Initial complete short circuit study shall be submitted and reviewed before Engineer will review Shop Drawings for switchboard and MCC equipment for incoming service equipment.
- B. Initial complete protective device coordination and arc flash studies shall be submitted within 90 days after approval of initial short circuit study.
- C. Revised short circuit, protective device coordination, and arc flash studies, and arc flash labels shall be submitted 10 days before energizing electrical equipment.
- D. Final short circuit, protective device coordination, and arc flash studies shall be completed prior to Project Substantial Completion. Final version of study shall include as-installed equipment, materials, and parameter data or settings entered into equipment based on study.
- E. Submit final arc flash labels described herein and in compliance with NEMA Z535.4 prior to Project Substantial Completion.

1.05 GENERAL STUDY REQUIREMENTS

- A. Equipment and component titles used in the studies shall be identical to equipment and component titles shown on Drawings.
- B. Perform studies using one of the following electrical engineering software packages:
 - 1. SKM Power Tools for Windows.
 - 2. ETAP.
 - 3. EDSA.
 - 4. Easy Power.
- C. Perform complete fault calculations for each proposed source combination.
 - 1. Source combination may include present and future power company supply circuits, large motors, or generators.
- D. Utilize proposed load data for study obtained from Contract Documents.
- E. Device coordination time-current curves for low voltage distribution system; include individual protective device time-current characteristics.

1.06 SHORT CIRCUIT STUDY

A. General:

1. Prepare in accordance with IEEE 399.
2. Use cable impedances based on copper conductors, except where aluminum conductors are specified or shown.
3. Use bus impedances based on copper bus bars, except where aluminum bus bars are specified or shown.
4. Use cable and bus resistances calculated at 25 degrees C.
5. Use medium-voltage cable reactances based on use of typical dimensions of shielded cables with 133 percent insulation levels.
6. Use 600-volt cable reactances based on use of typical dimensions of THHN/THWN conductors.
7. Use transformer impedances 92.5 percent of “nominal” impedance based on tolerances specified in IEEE C57.12.00.

B. Provide:

1. Calculation methods and assumptions.
2. Typical calculation.
3. Tabulations of calculated quantities.
4. Results, conclusions, and recommendations.
5. Selected base per unit quantities.
6. One-line diagrams.
7. Source impedance data, including electric utility system and motor fault contribution characteristics.
8. Impedance diagrams.
9. Zero-sequence impedance diagrams.

C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:

1. Electric utility’s supply termination point.
2. Main switchboard.
3. Low-voltage switchboards.
4. Motor control centers.
5. Branch circuit panelboards.
6. Future load contributions as shown on one-line diagram.

D. Provide bolted line-to-ground fault current study for areas as defined for three-phase bolted fault short circuit study.

- E. Verify:
 - 1. Equipment and protective devices are applied within their ratings.
 - 2. Adequacy of switchboard and motor control centers bus bars to withstand short circuit stresses.
 - 3. Cable and busway sizes for ability to withstand short circuit heating, in addition to normal load currents.

- F. Tabulations:
 - 1. General Data:
 - a. Short circuit reactances of rotating machines.
 - b. Cable and conduit material data.
 - c. Bus data.
 - d. Transformer data.
 - e. Circuit resistance and reactance values.
 - 2. Short Circuit Data (for each source combination):
 - a. Fault impedances.
 - b. X to R ratios.
 - c. Asymmetry factors.
 - d. Motor contributions.
 - e. Short circuit kVA.
 - f. Symmetrical and asymmetrical fault currents.
 - 3. Equipment Evaluation:
 - a. Equipment bus bracing, equipment short circuit rating, transformer, cable, busway.
 - b. Maximum fault current available.

- G. Written Summary:
 - 1. Scope of studies performed.
 - 2. Explanation of bus and branch numbering system.
 - 3. Prevailing conditions.
 - 4. Selected equipment deficiencies.
 - 5. Results of short circuit study.
 - 6. Comments or suggestions.

- H. Suggest changes and additions to equipment rating and/or characteristics.

- I. Notify Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

- J. Revise data for “as-installed” condition.

1.07 PROTECTIVE DEVICE COORDINATION STUDY

A. General:

1. Prepare in accordance with IEEE 242.
2. Proposed protective device coordination time-current curves for distribution system, graphically displayed on conventional log-log curve sheets.
 - a. Provide separate curve sheets for phase and ground fault coordination for each scenario.
 - b. Each curve sheet to have title and one-line diagram that applies to specific portion of system associated with time-current curves on that sheet. Limit number of devices shown to four to six.
 - c. Identify device associated with each curve by manufacturer type, function, and, if applicable, recommended tap, time delay, instantaneous and other settings recommended.
 - d. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
 - e. Apply motor protection methods that comply with NFPA 70.

B. Plot Characteristics on Curve Sheets:

1. Electric utility's relays.
2. Electric utility's fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
3. Medium-voltage equipment relays.
4. Medium-voltage and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
5. Low-voltage equipment circuit breaker trip devices, including manufacturers tolerance bands.
6. Pertinent transformer full-load currents at 100 percent.
7. Transformer magnetizing inrush currents.
8. Transformer damage curves; appropriate for system operation and location.
9. ANSI transformer withstand parameters.
10. Significant symmetrical and asymmetrical fault currents.
11. Motor overload relay settings for motors greater than 40 horsepower.
12. Ground fault protective device settings.
13. Other system load protective devices for largest branch circuit and feeder circuit breaker in each motor control center.

- C. Primary Protective Device Settings for Delta-Wye Connected Transformer:
 - 1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within transformer's characteristics curve, including a point equal to 58 percent of IEEE C57.12.00 withstand point.
 - 2. Secondary Line-To-Line Faults: 16 percent current margin between primary protective device and associated secondary device characteristic curves.
- D. Separate medium voltage relay characteristics curves from curves for other devices by at least 0.4-second time margin.
- E. Tabulate Recommended Protective Device Settings:
 - 1. Relays:
 - a. Current tap.
 - b. Time dial.
 - c. Instantaneous pickup.
 - d. Electronic settings data file.
 - 2. Circuit Breakers:
 - a. Adjustable pickups.
 - b. Adjustable time-current characteristics.
 - c. Adjustable time delays.
 - d. Adjustable instantaneous pickups.
 - e. I²t In/Out.
 - f. Zone interlocking.
 - g. Electronic settings data file.
- F. Written Summary:
 - 1. Scope of studies performed.
 - 2. Summary of protective device coordination methodology.
 - 3. Prevailing conditions.
 - 4. Selected equipment deficiencies.
 - 5. Results of coordination study.
 - 6. Appendix of complete relay and circuit breaker electronic setting files, submit electronic data files from manufacturer's software.
 - 7. Comments or suggestions.

1.08 ARC FLASH STUDY

- A. Perform arc flash hazard study after short circuit and protective device coordination study has been completed, reviewed and accepted.

- B. Perform arc flash study in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.
- C. Base Calculation: For each major part of electrical power system, determine the following:
 - 1. Flash hazard protection boundary.
 - 2. Limited approach boundary.
 - 3. Restricted approach boundary.
 - 4. Incident energy level.
- D. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items.
 - 1. Bus name.
 - 2. Bus voltage.
 - 3. Date of analysis.
- E. Produce bus detail sheets that list items in Paragraph Base Calculation and the following additional items:
 - 1. Bus name.
 - 2. Upstream protective device name, type, and settings.
 - 3. Bus line-to-line voltage.
- F. Produce arc flash evaluation summary sheet listing the following additional items:
 - 1. Bus name.
 - 2. Upstream protective device name, type, settings.
 - 3. Bus line-to-line voltage.
 - 4. Bus bolted fault.
 - 5. Protective device bolted fault current.
 - 6. Arcing fault current.
 - 7. Protective device trip/delay time.
 - 8. Breaker opening time.
 - 9. Solidly grounded column.
 - 10. Equipment type.
 - 11. Arc flash boundary.
 - 12. Limited approach boundary.
 - 13. Restricted approach boundary.
 - 14. Incident energy.
- G. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or

causes incident energy values greater than 8 cal/cm². Propose approaches to reduce energy levels.

- H. Prepare report summarizing arc flash study with conclusions and recommendations which may affect integrity of electric power distribution system. As a minimum, include the following:
1. Equipment manufacturer's information used to prepare study.
 2. Assumptions made during study.
 3. Reduced copy of one-line drawing; 11 inches by 17 inches maximum.
 4. Arc flash evaluations summary spreadsheet.
 5. Bus detail sheets.
 6. Arc flash warning labels printed in color on adhesive backed labels.

PART 2 PRODUCTS

2.01 ARC FLASH WARNING LABELS

- A. Printed in multicolor on adhesive backed labels. An example label is located following end of section in Figure 1.

PART 3 EXECUTION

3.01 GENERAL

- A. Adjust relay and protective device settings according to values established by coordination study.
- B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
- C. Notify Engineer in writing of required major equipment modifications.
- D. Provide laminated one-line diagrams (minimum size 11 inches by 17 inches) to post on interior of electrical room doors.
- E. Provide arc flash warning labels on equipment as specified in this section.

3.02 SUPPLEMENTS

- A. The supplement listed below, following "End of Section," is a part of this Specification:
1. Figure 1: Example Arc Flash Label.

END OF SECTION

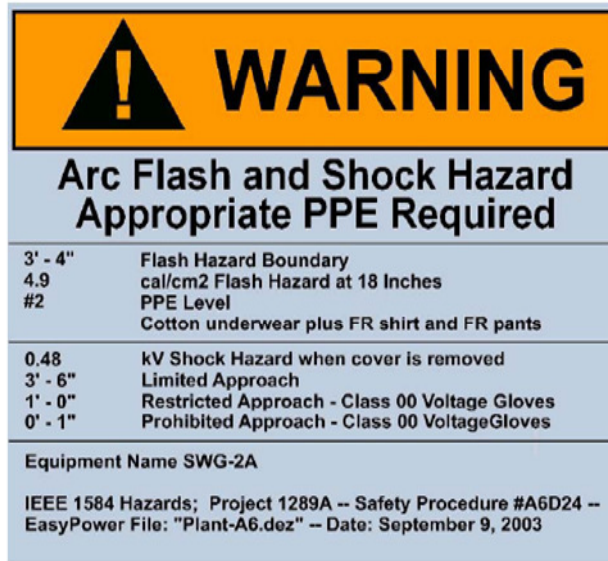


Figure 1
Example Arc Flash Label

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
 - a. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - b. D923, Standard Practice for Sampling Electrical Insulating Liquids.
 - c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
 - d. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
 - e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
 - f. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
 - g. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
 - h. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
 - i. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
 - j. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
2. 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 Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5kV through 500kV.
 - 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 AC Electric Machinery (2300V and Above) with High Direct Voltage.

- e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
 - g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
 - h. C2, National Electrical Safety Code.
 - i. C37.20.1, Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
 - j. C37.20.2, Standard for Metal-Clad Switchgear.
 - k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
 - l. C37.23, Standard for Metal-Enclosed Bus.
 - m. C62.33, Standard Test Specifications for Varistor Surge-Protective Devices.
- 3. Insulated Cable Engineers Association (ICEA):
 - a. S-93-639, 5-46 kV Shielded Power Cables for Use in the Transmission and Distribution of Electric Energy.
 - b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
 - c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.
 - 4. National Electrical Manufacturers Association (NEMA):
 - a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
 - b. PB 2, Deadfront Distribution Switchboards.
 - c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric 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. 70B, Recommended Practice for Electrical Equipment Maintenance.
 - c. 70E, Standard for Electrical Safety in the Workplace.
 - d. 101, Life Safety Code.
 - 7. National Institute for Certification in Engineering Technologies (NICET).
 - 8. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.

1.02 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
 - a. Schedule for performing inspection and tests.
 - b. Sample copy of equipment and materials inspection form(s).
 - c. Sample copy of individual device test form.
 - d. Sample copy of individual system test form.
2. Energization Plan: Prior to initial energization of electrical distribution equipment; include the following:
 - a. Staged sequence of initial energization of electrical equipment.
 - b. Lock-Out-Tag-Out plan for each stage of the progressive energization.
3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
4. Operation and Maintenance Data:
 - a. In accordance with Section 01 76 00, Operating and Maintenance Information.
 - b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.
5. Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left setpoints, programs, and device configuration files for:
 - a. Intelligent overload relays.
 - b. Variable frequency drives.
 - c. Power metering devices.
 - d. Uninterruptible power supplies.
 - e. Electrical communications modules.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.

- 5. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories.
- B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.
- C. Test instrument calibration shall be in accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

- A. Perform inspection and electrical tests after equipment listed herein has been installed.
- B. Perform tests with apparatus de-energized whenever feasible.
- C. Inspection and electrical tests on energized equipment shall be:
 - 1. Scheduled with Owner prior to de-energization.
 - 2. Minimized to avoid extended period of interruption to the operating plant equipment.
- D. Notify Owner at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Perform tests in accordance with requirements of Section 01 75 00, Testing, Equipment Startup, and Commissioning.
- B. Tests and inspections shall establish:
 - 1. Electrical equipment is operational within industry and manufacturer’s tolerances and standards.
 - 2. Installation operates properly.
 - 3. Equipment is suitable for energization.
 - 4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.
- C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer’s recommendations.
- D. Adjust mechanisms and moving parts of equipment for free mechanical movement.

- E. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.
- F. Verify nameplate data for conformance to Contract Documents and approved Submittals.
- G. Realign equipment not properly aligned and correct unlevelness.
- H. Properly anchor electrical equipment found to be inadequately anchored.
- I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.
- J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.
- K. Provide proper lubrication of applicable moving parts.
- L. Inform Engineer 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 Engineer, door and panel sections having dented surfaces.
 - 5. Repair or replace, as determined by Engineer, 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 Engineer, refinish entire assembly.

- O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Unbalance Corrections:
 - a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
 - b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:

1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.
3. Proper operation of indicating devices.
4. Improper blockage of air-cooling passages.
5. Integrity and contamination of bus insulation system.
6. Check key interlocking systems for:
 - a. Key captivity when device is in ON or CLOSED position.
 - b. Key removal when device is in ON or CLOSED position.
 - c. Closure attempt of device when key has been removed.
 - d. Correct number of keys in relationship to number of lock cylinders.
 - e. Existence of Other Keys Capable of Operating Lock Cylinders:
Destroy duplicate sets of keys.

7. Check nameplates for proper identification of: Equipment title and tag number with latest one-line diagram.
8. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.
9. Check bus and cable connections for high resistance by low resistance ohmmeter applied to bolted joints. Ohmic value to be zero.
10. 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.
 - c. Key exchange to operate devices in OFF-NORMAL positions.
11. Verify performance of each control device and feature.
12. Control Wiring:
 - a. Compare wiring to local and remote control and protective devices with elementary diagrams.
 - b. Proper conductor lacing and bundling.
 - c. Proper conductor identification.
 - d. Proper conductor lugs and connections.
13. Exercise active components.
14. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - b. Each phase of each bus section.
 - c. Phase-to-phase and phase-to-ground for 1 minute.
 - d. With breakers open.
 - e. With breakers closed.
 - f. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Current Injection Tests:
 - a. For entire current circuit in each section.
 - b. Secondary injection for current flow of 1 ampere.
 - c. Test current at each device.
3. Control Wiring:
 - a. Apply secondary voltage to control power and potential circuits.
 - b. Check voltage levels at each point on terminal boards and each device terminal.
4. Operational Test:
 - a. Initiate control devices.
 - b. Check proper operation of control system in each section.]

3.04 PANELBOARDS

- A. Visual and Mechanical Inspection: Include the following inspections and related work:
1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
 2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
 3. Check panelboard mounting, area clearances, and alignment and fit of components.
 4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
 5. Perform visual and mechanical inspection for overcurrent protective devices.
- B. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:
1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - b. Each phase of each bus section.
 - c. Phase-to-phase and phase-to-ground for 1 minute.
 - d. With breakers open.
 - e. With breakers closed.
 - f. Control wiring except that connected to solid state components.
 - g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 2. Ground continuity test ground bus to system ground.

3.05 DRY TYPE TRANSFORMERS

- A. Visual and Mechanical Inspection:
1. Physical and insulator damage.
 2. Proper winding connections.
 3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
 4. Defective wiring.
 5. Proper operation of fans, indicators, and auxiliary devices.
 6. Removal of shipping brackets, fixtures, or bracing.
 7. Free and properly installed resilient mounts.
 8. Cleanliness and improper blockage of ventilation passages.

9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
 - d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - e. Insulation resistance test results to compare within 1 percent of adjacent windings.

3.06 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 not in conformance with manufacturer's minimum allowable bending radius where applicable.
 - d. Color coding conformance with specification.
 - 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 100.12, 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 neutrals and grounds are terminated for correct operation of protective devices.
- B. Electrical Tests for Conductors No. 4 and Larger:
1. Insulation Resistance Tests:
 - a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors.
 - b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
 - c. Evaluate ohmic values by comparison with conductors of same length and type.
 - d. Investigate values less than 50 megohms.
 2. Continuity test by ohmmeter method to ensure proper cable connections.
- C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.07 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

- A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 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 100.12.
 6. Operate breaker to verify smooth operation.
 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 megohmmeter for 480-volt 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 100.1.
2. Contact Resistance Tests:
 - a. Contact resistance in microhms across each pole.
 - b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
 - a. Long-time minimum pickup and delay.
 - b. Short-time pickup and delay.
 - c. Ground fault pickup and delay.
 - d. Instantaneous pickup by run-up or pulse method.
 - e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
 - g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.08 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.09 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, panelboard, and switchboard assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, and switchboard 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.

B. Electrical Tests:

1. Fall-of-Potential Test:
 - a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
 - b. Main ground electrode system resistance to ground to be no greater than 5 ohm(s).

3.10 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 10 horsepower 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 functionality and proper operation.
 - e. Excessive vibration, in excess of values in NETA ATS, Table 100.10.
5. Check operation of space heaters.

3.11 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 drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
 - a. Closure attempt of device when door is in OFF position.
 - b. Opening attempt of door when device is in ON position.
8. Check key interlocking systems for:
 - a. Key captivity when device is in ON position.
 - b. Key removal when device is in OFF position.
 - c. Closure attempt of device when key has been removed.

- d. Correct number of keys in relationship to number of lock cylinders.
- e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
 - a. Equipment title and tag number with latest one-line diagram.
 - b. Circuit breakers.
 - c. Starters.
10. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
11. Verify current and potential transformer ratios conform to Contract Documents.
12. Check bus connections for high resistance by low-resistance ohmmeter: Ohmic value to be zero.
13. 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.
 - c. Key exchange to operate devices in OFF-NORMAL positions.
14. Verify performance of each control device and feature furnished as part of motor control center.
15. 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.
16. Exercise active components.
17. Inspect contactors for:
 - a. Correct mechanical operations.
 - b. Correct contact gap, wipe, alignment, and pressure.
 - c. Correct torque of connections.
18. Compare overload heater rating with full-load current for proper size.
19. Compare motor protector with motor characteristics for proper size.
20. 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 megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - 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 100.1.
2. Current Injection through Overload Unit at 300 Percent 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 board and each device terminal.
 - c. Insulation resistance test at 1,000 volts dc on control wiring, except that connected to solid state components; 1 megohm minimum insulation resistance.
4. Operational test by initiating control devices to affect proper operation.

3.12 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.
2. Check connections for high resistance by low-resistance ohmmeter.
3. Check positive mechanical and electrical interlock between normal and alternate sources.
4. Check for proper operation:
 - a. Manual transfer function switch.
 - b. Generator under load and nonload conditions.
 - c. Auto-exerciser of generator under load and no-load conditions.
5. Verify settings and operation of control devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1, for each phase with switch CLOSED in both source positions.
 - b. Phase-to-phase and phase-to-ground for 1 minute.
 - c. Test values in accordance with manufacturer's published data.
2. Contact Resistance Test:
 - a. Contact resistance in microhms across each switch blade for both source positions.
 - b. Investigate values exceeding 500 micro-ohms.

- c. Investigate values deviating from adjacent pole by more than 50 percent.
3. Set and calibrate in accordance with Specifications, manufacturer's recommendations, and information provided by Engineer.
 - a. Voltage and frequency sensing relays.
 - b. Time delay relays.
 - c. Engine start and shutdown relays.
4. Perform automatic transfer tests by:
 - a. Simulating loss of normal power.
 - b. Return to normal power.
 - c. Simulating loss of alternate power.
 - d. Simulating single-phase conditions for normal and alternate sources.
5. Monitor and verify operation and timing of:
 - a. Normal and alternate voltage sensing relays.
 - b. Engine-start sequence.
 - c. Timing delay upon transfer and retransfer.
 - d. Engine cool down and shutdown.
 - e. Interlocks and limit switch functions.
 - f. Engine cool down and shutdown feature.

END OF SECTION

SECTION 26 09 13
POWER MEASUREMENT AND CONTROL

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American National Standards Institute (ANSI).
 2. Institute for Electrical and Electronics Engineers, Inc. (IEEE):
 - a. C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
 - b. C37.90.1, Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
 - c. C57.13, Standard Requirements for Instrument Transformers.
 3. International Electrotechnical Commission (IEC):
 - a. 60255-5, Electrical Relays—Part 5: Insulation Coordination for Measuring Relays and Protection Equipment—Requirements and Tests.
 - b. 60255-22-4, Measuring Relays and Protection Equipment—Part 22-4: Electrical Disturbance Tests—Electrical Fast Transient/Burst Immunity Tests.
 - c. 60688, Electrical Measuring Transducers for Converting a.c. Electrical Quantities to Analogue or Digital Signals.
 - d. 60870-5-104, Telecontrol Equipment and Systems—Part 5-104: Transmission Protocols—Network Access for IEC 60870-5-101 Using Standard Transport Profiles.
 - e. 61850, Communication Network and Systems in Substations.
 4. Telecommunications Industry Association (TIA):
 - a. 232-F, Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
 - b. 485-A, Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems.
 5. National Electrical Manufacturers Association (NEMA):
 - a. C12.1, Electric Meters Code for Electricity Metering.
 - b. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

1.02 DEFINITIONS

- A. AFD: Adjustable Frequency Drive.
- B. CT: Current Transformer.

- C. DNP: Distributed Network Protocol.
- D. LCD: Liquid Crystal Display.
- E. LED: Light Emitting Diode.
- F. MPR: Motor Protection Relay.
- G. PLC: Programmable Logic Controller.
- H. RTD: Resistance Temperature Detectors.
- I. UCA: Utility Communications Architecture.
- J. VT: Voltage Transformer.

1.03 SUBMITTALS

A. Action Submittals:

1. Instruction manuals for each type of device.
2. Potential and current schematic diagrams.
3. Control and metering schematic diagrams.
4. Interconnection wiring diagrams.
5. Installation and mounting requirements.
6. Complete descriptive literature and renewal parts data.

B. Informational Submittals:

1. Programming software used to configure devices, along with settings files necessary to reload or revise settings as left by Contractor.
2. Operation and Maintenance Data as specified in Section 01 76 00, Operating and Maintenance Information.

PART 2 PRODUCTS

2.01 DIGITAL POWER METER (DPM)

A. General:

1. Solid state device with LED displays.
2. Direct voltage input up to 600V ac.
3. Current input via current transformer with 5-ampere secondary.
4. Programmable current and potential transformer ratios.
5. Programmable limits to activate up to four alarms.

6. Selectable Voltage Measurements: Line-to-line or line-to-neutral and wye or delta.
7. Communication: Ethernet TCP/IP.

B. Simultaneous Display:

1. Volts, three-phase.
2. Amperes, three-phase.
3. Kilowatts.
4. Kilowatt hours.
5. Power factor.
6. Frequency.
7. kVAR.
8. kVARh.
9. %THD.
10. kVA.
11. kVAh.
12. Voltage Rating: 20V ac to 576V ac.
13. Manufacturers and Products:
 - a. Eaton; Power Xpert 2200 series.
 - b. Allen Bradley; Powermonitor 3000.

2.02 INSTRUMENT TRANSFORMERS

A. Current Transformer (CT), 600 Volts and Below:

1. Type: Donut.
2. Accuracy: 0.3 at burden imposed by meters and instruments.
3. Shorting type terminal boards for current transformer leads.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In accordance with manufacturer's written instructions.
- B. As defined in Section 26 08 00, Commissioning of Electrical Systems.

3.02 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative: Present at distribution equipment factory, Site, and classroom designated by Owner, for the minimum person-days listed below, travel time excluded:
1. Two person-days to enter, confirm, and assist in communications configuration at the distribution equipment. Device settings to be based on values generated in the device coordination study.
 2. Two person-days for initial energization and startup of distribution system equipment.
 3. Two person-days for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by the Engineer.
- B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 75 00, Testing, Equipment Startup, and Commissioning.

END OF SECTION

**SECTION 26 14 13
SWITCHBOARDS****PART 1 GENERAL**

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. National Electrical Manufacturers Association (NEMA):
 - a. PB 2, Deadfront Distribution Switchboards.
 - b. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 3. Underwriters Laboratories (UL):
 - a. 489, Standard for Safety for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - b. 891, Standard for Safety for Switchboards.
 - c. 1561, Standard for Safety for Dry-Type General Purpose and Power Transformers.

1.02 SUBMITTALS

- A. Action Submittals:
1. Descriptive product information.
 2. Itemized Bill of Material.
 3. Dimensional drawings.
 4. Operational description.
 5. One-line, three-line, and control schematic drawings.
 6. Connection and interconnection drawings.
 7. Circuit Breakers: Copies of time-current characteristics.
 8. Ground Fault Protection: Relay time-current characteristics.
 9. Bus data.
 10. Incoming line section equipment data.
 11. Transformer section equipment data.
 12. Conduit entrance locations.
 13. Anchoring instructions and details.
 14. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.
2. Manufacturer’s installation instructions.
3. Factory Test Report.
4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
5. Operation and Maintenance Data: As specified in Section 01 76 00, Operating and Maintenance Information.
6. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services .

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton.
2. General Electric.
3. Siemens.
4. Square D.

2.02 GENERAL REQUIREMENTS

- A. Equipment suitable for 480-volt, three-phase, three-wire solid grounded-wye ungrounded electrical system having available short-circuit current at line terminals of amperes rms symmetrical as shown on Drawings.
- B. Comply with NEMA PB 2 and UL 891.

- C. Switchboard and its major components to be manufactured and assembled by single manufacturer in order to achieve standardization for appearance, operation and maintenance, spare parts replacement, and manufacturer's services.
- D. Lifting lugs on equipment and devices weighing over 100 pounds.
- E. Operating Conditions:
 - 1. Ambient Temperature: Maximum 40 degrees C.
 - 2. Equipment shall be fully rated without derating for the above operating conditions.

2.03 STATIONARY STRUCTURE

- A. Type: NEMA PB 2 construction, dead front, completely metal enclosed, self-supporting.
- B. Sections bolted together to form one rigid assembly capable of being moved into position and bolted directly to floor without use of floor sills.

2.04 ENCLOSURE

- A. Equipment Finish: Baked enamel applied over rust-inhibiting phosphated base coating.
 - 1. Color:
 - a. Exterior: Gray finish as approved by Engineer.
 - b. Interior: White.
 - c. Unpainted Parts: Plated for corrosion resistance.
- B. Indoor Enclosure: NEMA 250, Type 1:
 - 1. Rear, full-height, bolt-on panels for each enclosure section. Equipment shall be installed such that rear panel shall be located against wall.
 - 2. Cable Termination Access: Padlock provision.
 - 3. Front Access:
 - a. Service line and load terminations, internal devices, device and bolted bus connections, and protective device removal, serviceable from front only.
 - b. Sections aligned across back to permit placement flush against wall.
 - c. Working Space: As required by NFPA 70.
 - 4. Transition sections as required or shown.

5. Side and Top Covers: Removable, captive, screw-on plates with formed edges on each side.
6. Front Cover: Hinged door with formed edges.

2.05 BUSWORK

- A. Material: Phase noninsulated copper throughout entire length of sufficient cross section to limit temperature rise at rated current to 55 degrees C.
- B. Bus Arrangement: A-B-C, left-to-right, top-to-bottom, and front-to-rear, as viewed from front.
- C. Brace for short-circuit currents 65,000 amperes rms symmetrical.
- D. Main Horizontal Bus: Nontapered, continuous current rating as shown.
- E. Neutral Bus: None.
- F. Ground Bus:
 1. Copper.
 2. Rating: 500 amperes.
 3. Bolted to each vertical section.
 4. Bus Connections and Joints: Bolted with Belleville washers.
- G. Extend each bus entire length of switchboard.

2.06 PROTECTIVE DEVICES

- A. Molded-Case Circuit Breakers:
 1. Protective Devices: Individually mounted, suitable for use with 75 degree C wire at full 75 degree C ampacity when mounted in switchboard.
 2. Arrangement: Switchboard shall two breakers that function as a manual transfer switch and service entrance equipment. Breakers shall be interlocked with a keyed interlock.
 3. Breakers 600-Ampere Frame and Above: Solid-state trip unit. Breakers shall be percent rated.
 4. Interrupting Rating: 65,000 amperes rms symmetrical at rated voltage of 480.
 5. Mechanical interlock to prevent opening compartment door while breaker is in closed position.

- B. Ground Fault Protection:
 - 1. Ground sensor encircling phase conductors and neutral conductor, where used.
 - 2. Solid-state sensing relay and monitor/test panel.
 - 3. Zero sequence current detection, adjustable over range shown.
 - 4. Monitor panel with fault detection indicating light, test, and reset buttons.
 - 5. Control Power Source: Suitable to operate circuit protective device when connected to faulted phase conductor.

- C. Breaker Accessories: Provide keyed interlock such that only one circuit breaker can be closed at a time.

2.07 SOLID-STATE TRIP UNIT

- A. Flux-shift trip and current sensors.

- B. Protective Programmers:
 - 1. Self-powered, automatic rms sensing micro-electronic processor.
 - 2. No external relays or accessories.
 - 3. Printed circuit cards with gold-plated contacts.
 - 4. Programmable Controls:
 - a. Fixed-point, with repetitive accuracy and precise unit settings.
 - b. Trip adjustments made by nonremovable, discrete step switching.
 - 5. Field-Installable Rating Plugs:
 - a. Long-time pickup LED indicator and test receptacle.
 - b. Matching load and cable requirements.
 - c. Interlocked with tripping mechanism.
 - d. Breaker to remain trip-free with plug removed.
 - e. Keyed rating plugs to prevent incorrect application.
 - 6. Long-time pickup light.
 - 7. Selective Coordination Time/Current Curve Shaping Adjustable Functions:
 - a. Current setting.
 - b. Long-time pickup.
 - c. Long-time delay.
 - d. Instantaneous pickup with short-time for both breakers.
 - e. Short-time pickup for both breakers.
 - f. Short-time delay for both breakers with I2T function, and IN-OUT switch.
 - g. Ground fault pickup.

- h. Ground fault delay with I2T function.
 - i. Zone selective interlock.
 - 8. Fault Trip Indicators: Mechanical push-to-reset type for overload and short-circuit overload plus ground fault trip.
 - 9. Rejection Pins: For each programmer frame size.
- C. Phase Current Sensors:
 - 1. Single-ratio type.
 - 2. Fixed, mounted on breaker frame.
 - 3. Molded epoxy construction.
 - 4. One toroidal type for each phase.
- D. Ground Fault Sensor:
 - 1. Neutral bar single-ratio CT mounted in cable compartment.
 - 2. Molded epoxy construction.
 - 3. Shorting bar.

2.08 CONTROL WIRING

- A. Control, Instrumentation, and Power/Current Circuits: NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts.
- B. Transducer Output/Analog Circuits: Shielded cable rated 600 volts, 90 degrees C minimum.
- C. Conductor Lugs: Preinsulated, self-locking, spade-type, with reinforced sleeves.
- D. Identification: Individually, with permanent wire markers at each end.
- E. Enclose in top and vertical steel wiring troughs, and front-to-rear in nonmetallic wiring troughs.
- F. Splices: Not permitted in switchboard wiring.

2.09 TERMINAL BLOCKS

- A. Enclosed in steel wiring troughs.
- B. Rated 600 volts, 30 amperes minimum, one-piece barrier type with strap screws.
- C. Shorting type for current transformer leads.

- D. Provide terminal blocks for:
 - 1. Conductors connecting to circuits external to switchboard.
 - 2. Internal circuits crossing shipping splits.
 - 3. Equipment parts requiring replacement and maintenance.
- E. Spare Terminals: Not less than 20 percent.
- F. Group terminal blocks for external circuit wiring leads.
- G. Maintain 6-inch minimum space between columns of terminal blocks.
- H. Identification: Permanent, for each terminal and columns of terminal blocks.
- I. Manufacturer and Product: General Electric; Type EB-5.

2.10 KEY INTERLOCK

- A. Mechanical lock cylinder within breaker compartments as shown on Drawings.
- B. Key and Lock Cylinder Type: Superior (or equal).
- C. Keys to be captive when breakers are closed.
- D. Two main breaker arrangement.

2.11 IDENTIFICATION

- A. Nameplates:
 - 1. Master:
 - a. Deep-etched aluminum, with manufacturer's name and model number.
 - b. Riveted to main vertical section.
 - 2. Circuit Breaker Cubicle and Door-Mounted Device:
 - a. Engraved, acrylic.
 - b. Color: Black with white.
 - c. Characters: Block-type, 3/16-inch high.
 - d. Size: Manufacturer's standard.
 - e. Inscription: As shown on one-line diagram.
 - f. Blank plates for future spaces.
 - g. Attachment Screws: Self-tapping.

B. Section Identification:

1. Stamped metallic, riveted to each vertical section.
2. Serial number, bus rating, and section reference number.
3. Size: Manufacturer's standard.

C. Cubicle Labels:

1. Nonmetallic, applied inside each cubicle compartment.
2. Device serial number, rating, and description.

D. Control Switches: Deep etched, aluminum escutcheon plate.**E. Switchboard Sign:**

1. Two sign on front of switchboard.
2. Engraved, acrylic.
3. Size: Manufacturer's standard.
4. Color: Red with white.
5. Characters: Gothic-type, 1 inch high.
6. Inscription: DANGER/HIGH VOLTAGE/KEEP OUT.
7. Attachment: Four rivets each sign.

2.12 FACTORY TESTING

- A. Performance tests in accordance with UL 891 and production tests in accordance with NEMA PB-2.

PART 3 EXECUTION**3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions and recommendations.
- B. Secure to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.
- C. Install plumb and in longitudinal alignment with pad or wall.
- D. Coordinate terminal connections with installation of secondary feeders.

END OF SECTION

SECTION 26 20 00
LOW-VOLTAGE AC INDUCTION MOTORS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Bearing Manufacturers Association (ABMA):
 - a. 9, Load Ratings and Fatigue Life for Ball Bearings.
 - b. 11, Load Ratings and Fatigue Life for Roller Bearings.
 2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
 - b. 620, Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines.
 - c. 841, Standard for Petroleum and Chemical Industry—Premium Efficiency Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp).
 3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. C50.41, Polyphase Induction Motors for Power Generating Stations.
 - c. MG 1, Motors and Generators.
 4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 5. Underwriters Laboratories (UL):
 - a. 83, Standard for Safety for Thermoplastic-Insulated Wire and Cables.
 - b. 674, Standard for Safety for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.
 - c. 2111, Standard for Safety for Overheating Protection for Motors.

1.03 DEFINITIONS

- A. CISD-TEFC: Chemical industry, severe-duty enclosure.
- B. DIP: Dust-ignition-proof enclosure.
- C. EXP: Explosion-proof enclosure.
- D. Inverter Duty Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.
- E. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.
- F. ODP: Open drip-proof enclosure.
- G. TEFC: Totally enclosed, fan-cooled enclosure.
- H. TENV: Totally enclosed, nonventilated enclosure.
- I. WPI: Open weather protected enclosure, Type I.
- J. WPII: Open weather protected enclosure, Type II.

1.04 SUBMITTALS

- A. Action Submittals:
 - 1. Descriptive information.
 - 2. Nameplate data in accordance with NEMA MG 1.
 - 3. Additional Rating Information:
 - a. Service factor.
 - b. Locked rotor current.
 - c. No load current.
 - d. Multispeed load classification (for example, variable torque).
 - e. Adjustable frequency drive motor load classification (for example, variable torque) and minimum allowable motor speed for that load classification.
 - f. Guaranteed minimum full load efficiency and power factor.
 - 4. Enclosure type and mounting (such as, horizontal, vertical).
 - 5. Dimensions and total weight.
 - 6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
 - 7. Bearing type.
 - 8. Bearing lubrication.

9. Bearing life.
10. Space heater voltage and watts.
11. Description, ratings, and wiring diagram of motor thermal protection.
12. Motor sound power level in accordance with NEMA MG 1.
13. Maximum brake horsepower required by the equipment driven by the motor.
14. Description and rating of submersible motor moisture sensing system.

B. Informational Submittals:

1. Factory test reports.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
3. Operation and Maintenance Data: As specified in Section 01 76 00, Operating and Maintenance Information.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. General Electric.
2. Reliance Electric.
3. MagneTek.
4. Siemens Energy and Automation, Inc., Motors and Drives Division.
5. Baldor.
6. U.S. Electrical Motors.
7. TECO-Westinghouse Motor Co.
8. Toshiba International Corp., Industrial Division.
9. WEG Electric Motors Corp.

2.02 GENERAL

- A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.
- B. In order to obtain single source responsibility, use a single supplier to provide drive motor, its driven equipment, and specified motor accessories.
- C. Meet requirements of NEMA MG 1.
- D. For motors used in hazardous (classified) locations, Class I, Division 1, Groups B, C, and D, and Class II, Division 1, Groups E, F, and G provide motors that conform to UL 674 and have an applied UL listing mark.

- E. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.
- F. Lifting lugs on motors weighing 100 pounds or more.
- G. Operating Conditions:
 1. Maximum ambient temperature not greater than 40 degrees C.
 2. Motors shall be suitable for operating conditions without reduction being required in nameplate rated horsepower or exceeding rated temperature rise.
 3. Overspeed in either direction in accordance with NEMA MG 1.

2.03 HORSEPOWER RATING

- A. As designated in motor-driven equipment specification.
- B. Constant Speed Applications: Brake horsepower of driven equipment at any operating condition not to exceed motor nameplate horsepower rating, excluding service factor.
- C. Adjustable Frequency and Adjustable Speed Applications (Inverter Duty Motor): Driven equipment brake horsepower at any operating condition not to exceed motor nameplate horsepower rating, excluding service factor.

2.04 SERVICE FACTOR

- A. Inverter-duty Motors: 1.0 at rated ambient temperature, unless otherwise noted.
- B. Other Motors: 1.15 minimum at rated ambient temperature, unless otherwise noted.

2.05 VOLTAGE AND FREQUENCY RATING

- A. System Frequency: 60 Hz.
- B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specification:

Voltage Rating		
Size	Voltage	Phase
1/2 hp and smaller	115	1
3/4 hp through 400 hp	460	3

- C. Suitable for full voltage starting.
- D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

2.06 EFFICIENCY AND POWER FACTOR

- A. For all motors except single-phase, under 1 hp, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:
 - 1. Efficiency:
 - a. Tested in accordance with NEMA MG 1, Paragraph 12.59.
 - b. Guaranteed minimum at full load in accordance with NEMA MG 1 Table 12-12, Full-load Efficiencies for NEMA Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound), or as indicated in motor-driven equipment specification.
 - 2. Power Factor: Guaranteed minimum at full load shall be manufacturer's standard or as indicated in motor-driven equipment specification.

2.07 LOCKED ROTOR RATINGS

- A. Locked rotor kVA Code F or lower, if motor horsepower not covered by NEMA MG 1 tables.
- B. Safe Stall Time: 12 seconds or greater.

2.08 INSULATION SYSTEMS

- A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.
- B. Three-phase and Integral Horsepower Motors: Unless otherwise indicated in motor-driven equipment specification, Class B or Class F at nameplate horsepower and designated operating conditions.

2.09 ENCLOSURES

- A. Enclosures to conform to NEMA MG 1.
- B. TEFC and TENV: Furnish with drain hole with porous drain/weather plug.
- C. Submersible: In accordance with Article Special Motors.

2.10 TERMINAL (CONDUIT) BOXES

- A. Oversize main terminal boxes for motors.
- B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.
- C. Except ODP, furnish gaskets between box halves and between box and motor frame.
- D. Minimum usable volume in percentage of that specified in NEMA MG 1, Section 1, Paragraph 4.19 and NFPA 70, Article 430:

Terminal Box Usable Values		
Voltage	Horsepower	Percentage
Below 600	15 through 125	500

- E. Terminal for connection of equipment grounding wire in each terminal box.
- F. Coordinate motor terminal box conduit entries versus size and quantity of conduits shown on Drawings.

2.11 BEARINGS AND LUBRICATION

- A. Horizontal Motors:
 - 1. 3/4 hp and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
 - 2. 1 hp through 400 hp: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
 - 3. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and ABMA 11.
- B. Vertical Motors:
 - 1. Thrust Bearings:
 - a. Antifriction bearing.
 - b. Manufacturer’s standard lubrication 100 hp and smaller.
 - c. Oil lubricated 125 hp and larger.
 - d. Minimum 50,000 hours L-10 bearing life.
 - 2. Guide Bearings:
 - a. Manufacturer’s standard bearing type.
 - b. Manufacturer’s standard lubrication 200 hp and smaller.

- c. Oil lubricated 250 hp and larger.
- d. Minimum 100,000 hours L-10 bearing life.

C. Regreasable Antifriction Bearings:

- 1. Readily accessible, grease injection fittings.
- 2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:

- 1. Oil reservoirs with sight level gauge.
- 2. Oil fill and drain openings with opening plugs.
- 3. Provisions for necessary oil circulation and cooling.

E. Inverter Duty Rated Motors, Bearing Isolation: Motors larger than 50 hp shall have electrically isolated bearings to prevent stray current damage.

2.12 NOISE

- A. Measured in accordance with NEMA MG 1.
- B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

- A. In accordance with NEMA MG 1, Part 7.

2.14 EQUIPMENT FINISH

- A. External Finish: Prime and finish coat manufacturer's standard. Field painting in accordance with Section 09 90 00, Painting and Coating.
- B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

- A. Screen Over Air Openings: Stainless steel on motors with ODP, WPI, and WPII enclosures meeting requirements for guarded machine in NEMA MG 1, and attached with stainless steel screws.
- B. Winding Thermal Protection:
 - 1. Thermostats:
 - a. Motors for constant speed application and motors for adjustable speed application 40 hp and larger.

- b. Bi-metal disk or rod type thermostats embedded in stator windings.
- c. Automatic reset contacts rated 120 volts ac, 5 amps minimum, opening on excessive temperature. (Provide manual reset at motor controller.)
- d. Leads extending to separate terminal box for motors 100 hp and larger.

C. Space Heaters:

1. Provide winding space heaters with leads wired out to motor terminal box.
2. Provide extra hole or hub on motor terminal box as required.
3. Unless shown otherwise, heater shall be suitable for 120V ac supply, with wattage suitable for motor frame size.

D. Nameplates:

1. Raised or stamped letters on stainless steel or aluminum.
2. Display motor data required by NEMA MG 1, Paragraph 10.39 and Paragraph 10.40 in addition to bearing numbers for both bearings.
3. Premium efficiency motor nameplates to display NEMA nominal efficiency, guaranteed minimum efficiency, full load power factor, and maximum allowable kVAR for power factor correction capacitors.

E. Anchor Bolts: Provide meeting manufacturer's recommendations and of sufficient size and number for specified seismic condition.

2.16 SPECIAL MOTORS

- A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.
- B. Multispeed: Meet requirements for speeds, number of windings, and load torque classification indicated in motor-driven equipment specification.
- C. Inverter Duty Motor:
 1. Motor supplied power by adjustable voltage and adjustable frequency drives shall be inverter duty rated.
 2. Suitable for operation over entire speed range indicated.
 3. Provide forced ventilation where speed ratio is greater than published range for motor provided.
 4. Shaft Grounding Device: Motors larger than 30 hp shall be provided with shaft grounding brush or conductive micro fiber shaft grounding

ring. Shaft grounding device shall be solidly bonded to grounded motor frame per manufacturer’s recommendations.

- a. Manufacturers:
 - 1) Grounding Brush: Sohre Turbomachinery, Inc.
 - 2) Grounding Ring: EST-Aegis.

D. Submersible Pump Motor:

- 1. Manufacturers:
 - a. Reliance Electric.
 - b. ITT Flygt Corp.
- 2. At 100 Percent Load:

Submersible Pump Motors		
Horsepower	Guaranteed Minimum Efficiency	Guaranteed Minimum Power Factor
5 through 10	80	82
10.1 through 50	85	82
50.1 through 100	87	82
Over 100	89	82

- 3. Insulation System: Manufacturer’s standard Class B or Class F.
- 4. Motor capable of running dry continuously.
- 5. Enclosure:
 - a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
 - b. Listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous atmosphere.
 - c. Seals: Tandem mechanical.
- 6. Bearing and Lubrication:
 - a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
 - b. Minimum 15,000 hours L-10 bearing life.
- 7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.
- 8. Winding Thermal Protection:
 - a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
 - b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
 - c. Switch contacts rated at 5 amps, 120V ac.

9. Motor Seal Failure Moisture Detection:
 - a. Probes or sensors to detect moisture beyond seals.
 - b. Probe or sensor monitoring module for mounting in terminal junction box in field, suitable for operation from 120V ac supply.
 - c. Monitoring module with control power transformer, probe test switch and test light, and two independent 120V ac contacts, one opening and one closing when flux of moisture is detected.
10. Winding thermal protection and moisture detection specified above may be monitored by single device providing two independent 120V ac contacts, one closing and one opening on malfunction.
11. Connecting Cables:
 - a. One cable containing power, control, and grounding conductors.
 - b. Each cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
 - c. Length: 30 feet minimum.
 - d. UL 83 listed and sized in accordance with NFPA 70.

2.17 FACTORY TESTING

A. Tests:

1. In accordance with IEEE 112 for polyphase motors.
2. Routine (production) tests in accordance with NEMA MG 1. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency and power factor at 50 percent, 75 percent, and 100 percent of rated horsepower:
 - a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraph 12.59. and Paragraph 12.60.
 - b. For motors 500 hp and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
 - c. On motors of 100 hp and smaller, furnish copy of motor efficiency test report on an identical motor.
4. Provide test reports for all polyphase motors 100 hp and larger.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In accordance with manufacturer's instructions and recommendations.
- B. Align motor carefully and properly with driven equipment.
- C. Secure equipment to mounting surface with anchor bolts.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Institute of Electrical and Electronics Engineers (IEEE): C57.96, Guide for Loading Dry Type Transformers.
 2. National Electrical Contractor's Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
 3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. ST 20, Dry-Type Transformers for General Applications.
 - c. TP 1, Guide For Determining Energy Efficiency for Distribution Transformers.
 4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 5. Underwriters Laboratories Inc. (UL):
 - a. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - b. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - c. 1561, Standard for Dry-Type, General Purpose, and Power Transformers.

1.02 SUBMITTALS

- A. Action Submittals:
1. Descriptive information.
 2. Dimensions and weight.
 3. Transformer nameplate data.
 4. Schematic and connection diagrams.

PART 2 PRODUCTS

2.01 GENERAL

- A. UL 1561, NEMA ST 20, unless otherwise indicated.
- B. Dry-type, self-cooled, two-winding, with aluminum windings.

- C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- D. Efficiency: Meet or exceed values in Table 4.2 of NEMA TP 1.
- E. Maximum Sound Level per NEMA ST 20:
 - 1. 40 decibels for 0 kVA to 9 kVA.
 - 2. 45 decibels for 10 kVA to 50 kVA.
 - 3. 50 decibels for 51 kVA to 150 kVA.
 - 4. 55 decibels for 151 kVA to 300 kVA.
 - 5. 60 decibels for 301 kVA to 500 kVA.
- F. Overload capability: Short-term overload per IEEE C57.96.
- G. Wall Bracket: For three-phase units, 15 kVA to 45 kVA.
- H. Vibration Isolators:
 - 1. Rated for transformer's weight.
 - 2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
 - 3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
 - 4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.
- I. Manufacturers:
 - 1. General Electric Co.
 - 2. Square D Co.
 - 3. Eaton/Cutler-Hammer.

2.02 GENERAL PURPOSE TRANSFORMER

- A. Insulation Class and Temperature Rise: Manufacturer's standard.
- B. Core and Coil:
 - 1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
 - 2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:

1. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
2. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
3. Outdoor Locations: NEMA 250, Type 3R.
4. Corrosive Locations: NEMA 250, Type 3R stainless steel.

D. Voltage Taps:

1. Three-Phase, 3 kVA to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
2. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

E. Impedance: 4.5 percent minimum on units 75 kVA and larger.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with NECA and manufacturer's instructions.
- B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.
- C. Provide moisture-proof, flexible conduit for electrical connections.
- D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.
- E. Provide wall brackets for three-phase units, 15 kVA to 112 kVA.

END OF SECTION

**SECTION 26 24 16
PANELBOARDS****PART 1 GENERAL**

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE):
 - a. C62.1, Surge Arresters for Alternating Current Power Circuits.
 - b. C62.11, Standards for Metal-Oxide Surge Arrestors for AC Power Circuits.
2. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. 289, Application Guide for Ground Fault Circuit Interrupters.
 - c. AB 1, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 - d. KS 1, Enclosed Switches.
 - e. LA 1, Surge Arrestors.
 - f. PB 1, Panelboards.
 - g. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories Inc. (UL):
 - a. 67, Standard for Panelboards.
 - b. 98, Standard for Enclosed and Dead-Front Switches.
 - c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - e. 508, Standard for Industrial Control Equipment.
 - f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
 - g. 943, Standard for Ground-Fault Circuit-Interrupters.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.

- 2. Manufacturer’s shop drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
- 3. Tabulation of features for each panelboard to include the following:
 - a. Protective devices with factory settings.
 - b. Provisions for future protective devices.
 - c. Space for future protective devices.
 - d. Voltage, frequency, and phase ratings.
 - e. Enclosure type.
 - f. Bus and terminal bar configurations and current ratings.
 - g. Provisions for circuit terminations with wire range.
 - h. Short circuit current rating of assembled panelboard at system voltage.
 - i. Features, characteristics, ratings, and factory settings of auxiliary components.
- B. Informational Submittals: Manufacturer’s recommended installation instructions.

1.03 QUALITY ASSURANCE

- A. Listing and Labeling: Provide products specified in this Section that are listed and labeled as defined in NEC Article 100.

1.04 EXTRA MATERIALS

- A. Extra Materials: Furnish, tag, and box for shipment and storage the following material:

<u>Item</u>	<u>Quantity</u>
Touchup paint for panelboards	One half-pint container

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Panelboards shall be of the same manufacturer as equipment furnished under Section 26 24 19, Low-Voltage Motor Control.

2.02 GENERAL

- A. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

B. Wire Terminations:

1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
2. In accordance with UL 486E.

C. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated “continuous”, “100 percent”, etc., selected components and protective devices shall be rated for continuous load current at value shown.

D. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be no less than the indicated SCCR.**E. Overcurrent Protective Devices:**

1. In accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489.
2. Protective devices shall be adapted to panelboard installation.
 - a. Capable of device replacement without disturbing adjacent devices and without removing main bus.
 - b. Spaces: Cover openings with easily removable cover.
3. Series-Connected Short Circuit Ratings: Devices shall be fully rated; series-connected ratings unacceptable.

F. Circuit Breakers:

1. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
2. Noninterchangeable: In accordance with NEC.
3. Bus Connection: Bolt-on circuit breakers in all panelboards.
4. Trip Mechanism:
 - a. Individual permanent thermal and magnetic trip elements in each pole.
 - b. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
 - c. Two and three pole, common trip.
 - d. Automatically opens all poles when overcurrent occurs on one pole.

- e. Test button on cover.
 - f. Calibrated for 40 degrees C ambient, unless shown otherwise.
 - 5. Unacceptable Substitution:
 - a. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
 - b. Do not use tandem or dual circuit breakers in normal single-pole spaces.
 - 6. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
 - a. Ground fault sensor shall be rated same as circuit breaker.
 - b. Push-to-test button.
 - c. Reset button.
 - 7. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).
- G. Enclosures:
- 1. Provide as specified in Section 26 05 04, Basic Electrical Materials and Methods.
 - 2. Material: Type 1, Type 3R, and Type 3S shall be code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
 - 3. Finish: Rust inhibitor prime followed by manufacturer's standard gray baked enamel or lacquer.
- H. Bus:
- 1. Material: Tin-plated copper full sized throughout length.
 - 2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.
- I. Feeder Lugs: Main, feed-through, and neutral shall be replaceable, bolted mechanical or crimp compression type.
- J. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors, and bonded to box.
- 1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
 - 2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, etc.

- K. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.
 - 1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
 - 2. Provide individual termination points for all other neutral conductors.
- L. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.
- M. Special Features: Where indicated, provide the following features:
 - 1. Surge Arresters:
 - a. In accordance with NEMA LA 1, IEEE C62.1, and IEEE C62.11.
 - b. Comply with Section 26 43 00, Surge Protection Devices.
 - c. Coordinate impulse sparkover voltage with system voltage.
 - d. Provide protective device within panelboard as disconnecting means and short circuit protection per manufacturer's recommendation.
 - e. Provide factory mounting within panelboard utilizing UL-recognized mounting device.

2.03 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

- A. Protective Device Locking: Furnish provisions for handle padlocking for main and subfeed devices; also provide for branch devices where indicated.
- B. NEMA 250 Type 1 Branch Panelboard Enclosure:
 - 1. Front trim shall be secured to box with concealed trim clamps.
 - 2. Surface-mount panelboard front trim shall have same dimensions as box.
 - 3. Flush panelboards front trims shall overlap box nominal 3/4 inch on all sides.
 - 4. Door in panelboard front trim, with concealed hinges, shall provide access to protective device operating handles.
 - 5. Doors over 30 inches in height shall have multi-point latching.
 - 6. Door lock shall be secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
 - 7. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.

2.04 POWER DISTRIBUTION PANELBOARDS

A. Branch Protective Devices:

1. Locking: Furnish devices with provisions for handle padlocking.
2. Load Connections: Wire lugs shall be mechanical or crimp compression type, removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
3. Provide a nameplate for each circuit, blanks for spares.

PART 3 EXECUTION

3.01 GENERAL

- A. Install in accordance with NECA 407, NEMA PB 1.1 and manufacturers' written installation instructions.
- B. Install securely, plumb, in-line and square with walls.
- C. Install top of cabinet trim 78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.
- D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.
- E. Install filler plates in unused spaces.
- F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle, and wrap with nylon wire ties.

3.02 BRANCH CIRCUIT PANELBOARD

- A. Mount flush panels uniformly flush with wall finish.
- B. Provide typewritten circuit directory for each panelboard.

3.03 POWER DISTRIBUTION PANELBOARD

- A. Provide engraved identification for each protective device.

END OF SECTION

SECTION 26 24 19
LOW-VOLTAGE MOTOR CONTROL

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which shall be followed for this section:
1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
 2. National Electrical Contractors Association (NECA): 402, Standard for Installing and Maintaining Motor Control Centers.
 3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
 - b. ICS 1, Industrial Control and Systems: General Requirements.
 - c. ICS 2, Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - d. ICS 2.3, Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600V.
 - e. ICS 18, Motor Control Centers.
 - f. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
 4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 5. Underwriters Laboratories, Inc. (UL):
 - a. 98, Enclosed and Dead-Front Switches.
 - b. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - c. 845, Motor Control Centers.

1.02 DEFINITIONS

- A. CT: Current Transformer.
- B. LCD: Liquid Crystal Display.
- C. N.C.: Normally Closed.
- D. N.O.: Normally Open.
- E. THD: Total Harmonic Distortion.
- F. VT: Voltage Transformer.

1.03 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Itemized Bill of Material.
3. Dimensional drawings.
4. Front Panel Elevations.
5. Conduit entrance locations.
6. Bus data.
7. Protective Devices: Copies of time-current characteristics.
8. Anchoring instructions and details.
9. Typed Tabulation:
 - a. Motor name; tag (equipment) numbers as shown on Drawings.
 - b. Motor horsepower.
 - c. Nameplate full load current.
 - d. Measured load current and voltage.
 - e. Overload model number and relay setting.
 - f. Protective device trip settings.
 - g. Manufacturer's solid state starter switch or dip switch or program settings.
 - h. Attach above typed, tabulated data to a copy of starter manufacturer's overload heater or setting selection tables for starters provided.
10. Control diagrams.
11. One-line diagrams.
12. Schematic (elementary) diagrams.

B. Informational Submittals:

1. Manufacturer's installation instructions.
2. Factory test reports, certified.
3. Operation and Maintenance Data as specified in Section 01 76 00, Operating and Maintenance Information.
4. Complete set.

1.04 QUALITY ASSURANCE

- #### A. Provide products manufactured within scope of Underwriters Laboratories that conform to UL Standards and have applied UL Listing Mark.

1.05 DELIVERY, STORAGE, AND HANDLING

- #### A. Shipping Splits: Established by Contractor to facilitate ingress of equipment to final installation location within building.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of:
1. Eaton Electrical/Cutler-Hammer.
 2. GE Industrial Systems.
 3. Schneider Electric/Square D Services.
 4. Or equal.

2.02 GENERAL

- A. Like Items of Equipment: End product of one manufacturer and same manufacturer as low voltage switchboard and panelboards for standardization.
- B. Make adjustments necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.
- C. Controllers: NEMA ICS 1, NEMA ICS 2, Class A.
- D. Control Transformer:
1. Two winding, 120-volt secondary, primary voltage to suit.
 2. Two current-limiting fuses for primary circuit.
 3. One fuse in secondary circuit with blown fuse indicator.
 4. Mount within starter unit.
- E. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- F. Lifting lugs on equipment and devices weighing over 100 pounds.
- G. Anchor Bolts: Galvanized, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.
- H. Seismic Zone and Importance Factor shall be as specified in Section 01 61 00, Common Product Requirements.
- I. Operating Conditions:
1. Ambient Temperature: Maximum 40 degrees C.
 2. Altitude: 2,600 feet above sea level.
 3. Equipment to be fully rated.

- J. Enclosures: In accordance with NEMA 250.
- K. Equipment Finish:
 - 1. Electrocoating process applied over rust-inhibiting phosphated base coating.
 - 2. Exterior Color: Manufacturer's standard.

2.03 MOTOR CONTROL CENTERS

- A. General:
 - 1. In accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 18, and UL 845.
 - 2. Voltage Rating: As shown.
 - 3. Short Circuit Rating: As shown on Drawings.
 - 4. Main and branch circuit breakers, controllers, wire connections, and other devices to be front mounted and accessible, unless otherwise noted.
 - 5. NEMA ICS 18, Part 3.
 - a. Class: I.
 - b. Type: B.
- B. Enclosure:
 - 1. Type: NEMA 250 Type 1, indoor gasketed.
 - 2. Vertical Section Standard Indoor Dimensions for NEMA 1 Type:
 - a. Nominal, 90 inches high, 20 inches wide, 21 inches deep.
 - b. Alternative width dimensions of 24 inches and 30 inches are acceptable for oversize devices or panels.
 - c. Do not exceed space shown.
 - 3. Construction:
 - a. Sheet steel reinforced with channel or angle irons.
 - b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
 - c. Removable top cover plates.
 - d. Removable plates on end panels for future bus extension.
 - 4. Section Mounting: Removable formed-steel channel sills and lifting angles to meet specified seismic requirements.
 - 5. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
 - 6. Vertical Wiring Compartment:
 - a. Full height, isolated from unit starters with separate hinged door and tie supports.
 - b. No terminal blocks allowed in vertical wireway compartment.

7. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
8. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
9. Door Interlocking: Mechanically interlock starter and feeder doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access and energizing at any time by qualified individual.
10. External disconnect handles with ON/OFF and trip positions showing, padlockable in OFF position with up to three-lock capability.
11. Cable Entrance: Main leads enter from bottom; control and feeder circuits enter from top and bottom.

C. Bus:

1. Horizontal Power Bus:
 - a. Three-phase tin-plated copper, entire width of control center, rated as shown.
 - b. Tin or silver-plated at joints.
 - c. Construct to allow future extension of additional sections.
 - d. Pressure type solderless lugs for each incoming line cable.
 - e. Isolated from top horizontal wireway.
2. Vertical Power Bus:
 - a. Three-phase tin-plated copper, full height of section, rated 300 amperes unless higher amperage is required.
 - b. Tin-plated at joints.
 - c. Sandwich type bus insulation providing deadfront construction with starter units removed except for bus stab openings.
 - d. Insulated and isolated barrier, complete with shutters.
3. Neutral Bus: None.
4. Ground Bus:
 - a. Copper, bare, rated 600 amperes, entire width of control center.
5. Bus Bracing: As shown.

D. Motor Controller Unit:

1. Provide indicated individual components and control devices including pushbuttons, selector switches, indicating lights, control relays, time delay relays, and elapsed time meters as specified in Section 26 05 04, Basic Electrical Materials and Methods.
2. Construction:
 - a. Drawout combination type with stab connections for starters NEMA ICS, Size 5 and smaller.

- b. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 6 and larger.
 - c. Readily interchangeable with starters of similar size.
 - d. Pull-apart unit control wiring terminal boards on all units.
3. Starters:
- a. NEMA ICS 18, standard rating, except none smaller than NEMA ICS, Size 1.
 - b. Rating: Horsepower rated at 600 volt, UL labeled for 65,000 amperes at 480 volts short circuit capacity with overload protection.
 - c. Three-phase, nonreversing, unless specified otherwise.
 - d. Disconnect Type: Motor circuit protector.
 - e. Combination Full Voltage, Magnetic Starter:
 - 1) Control: As shown on Drawings.
 - f. Communications: None.
 - g. Padlockable operating handle when de-energized with up to three-lock capability.
 - h. Unit door interlocked to prevent opening when disconnect is in closed position.
 - i. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
 - j. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.
4. Disconnecting Device:
- a. As indicated.
 - b. Padlockable in OPEN position for up to three locks.
5. Circuit Breaker:
- a. Meet requirements of UL 489.
 - b. Molded case with manufacturer's recommended trip setting for maximum motor protection.
 - c. Thermal-magnetic trip or magnetic trip only as shown.
 - d. Tripping indicated by operating-handle position.
 - e. Interrupting capacity required for connection to system with short-circuit capacity indicated.
6. Solid State Motor Overload Protection:
- a. Inverse-time-limit characteristic.
 - b. Phase loss, phase unbalance and Class II ground fault protection.
 - c. Current operated electronic circuitry with adjustable trip.
 - d. Class 10/20/30 relay trip, switch selectable.
 - e. One N.O. auxiliary contact for remote monitoring.
 - f. Manual reset.
 - g. Provide in each ungrounded phase.
 - h. Mount within starter unit.
 - i. Communications: Ethernet.

7. Motor Thermal Protector Interface: Manual-reset interposing relay for connection to motor-mounted thermal protector system.
- E. Control Unit:
1. Disconnecting Device: Pull-apart terminal blocks capable of de-energizing external source control circuits in unit.
 2. Control Devices: As indicated and as specified in Section 26 05 04, Basic Electrical Materials and Methods.
 3. Control Wiring:
 - a. Copper, 14 AWG, minimum.
 - b. Permanent sleeve type markers with wire numbers applied to each end of wires.
 - c. Terminate wires using insulated locking fork or ring type crimp terminals.
 - d. Terminate current transformer leads on shorting type terminal blocks.
- F. Main Protective Device and Feeder Unit:
1. Construction: As specified in Paragraph Motor Controller Unit.
 2. Incoming Service Feeder: Cable.
 3. Electronic Trip Circuit Breaker:
 - a. In accordance with UL 489.
 - b. Main protective devices and feeders as shown.
 - c. UL labeled as suitable for service entrance.
 - d. Insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
 - e. Solid-state current control with adjustable ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip, and adjustable ground fault trip and delay band.
 - f. Setting adjustments to be covered by a sealable, tamper-proof, transparent cover (insulated case breakers only) or by compartment door (for other breakers).
 - g. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping for test purposes and to trip breaker quickly in emergency situation.
 4. Molded Case Circuit Breaker:
 - a. In accordance with UL 489.
 - b. Feeder protective devices less than 400A.
 - c. Thermal-magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
 - d. Indicate tripping by operating-handle position.

- e. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
- G. Digital Instruments:
- 1. Digital Power Meter: As specified in Section 26 09 13, Power Measurement and Control.
- H. Key Interlocks:
- 1. Two Main and One Tie Breaker Arrangement:
 - a. Two keys available for each group of three locks.
 - b. Two out of three breakers closed at any time.
- I. SPD: As specified in Section 26 43 00, Surge Protective Devices.
- J. Pushbuttons, Indicating Lights, Selector Switches, Elapsed Time Meters, Control Relays, Time-Delay Relays, and Reset Timers: As specified in Section 26 05 04, Basic Electrical Materials and Methods.
- K. Nameplates:
- 1. Laminated plastic; black, engraved to white core.
 - 2. Provide for each motor control center and each unit.
 - 3. Engrave with inscription shown on single-line diagram.
 - 4. Provide blank nameplates on spaces for future units.
 - 5. Attach with stainless steel panhead screws on face of control center.
 - 6. Provide laminated plastic instruction for electrical equipment.
 - a. Main-tie-Main Instruction for 3100MCC11S:
 - 1) Title: "Main-Tie-Main Instructions:"
 - 2) Paragraph: "Main-Tie-Main breaker configuration of this MCC allows for half of the MCC to be de-energized at a time to allow safe maintenance of the de-energized portion. To de-energize a portion of the MCC open up the tie breaker and the main breaker of the portion to be de-energized. Both main breakers must be open to de-energize the whole bus. See owner's manual for details."
 - b. Manual Transfer Switch Instruction for 3102SWB11S:
 - 1) Title: "Keyed Interlock Instruction:"
 - 2) Paragraph: "Breakers are interlocked with keyed locks so that only one breaker can be closed at a time. Do not bypass interlocks and close both breakers at the same time. Insert and turn key in lock to close breaker. Open breaker and turn key to remove the key."

2.04 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Applicable Standards: NEMA ICS 18, UL 845, and NEC Article 430, Part VIII.
2. Perform standard factory inspection and tests in accordance with NEMA requirements to verify components have been designed to Specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
3. Actual operation shall be performed wherever possible. Otherwise, inspect and perform continuity checks.
4. Verify component devices operated correctly in circuits as shown on diagrams or as called for in Specification.
5. Control Circuits and Devices:
 - a. Energize circuit at rated voltage.
 - b. Operate control devices.
 - c. Perform continuity check.
6. Instruments, Meters, Protective Relays, and Equipment:
 - a. Verify devices functioned by energizing potential to rated values with connection to devices made at outgoing terminal blocks.
 - b. Verify protective relays operated for functional checks and trips manually initiated to verify functioning of operation for indicator and associated circuits.
7. Perform dielectric tests on primary circuits and equipment, except potential transformers. Tests shall be made phase-to-phase and phase-to-around with 60-cycle test voltages applied for 1 second at 2,640 volts.
8. Verify equipment passed tests and inspection.
9. Provide standard factory inspection and test checklists, and final certified and signed test report.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install equipment in accordance with NEMA ICS 2.3, IEEE C2, NECA 402, Submittals, and manufacturer's written instructions and recommendations.
2. Secure equipment to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.
3. Install equipment plumb and in longitudinal alignment with pad or wall.
4. Coordinate terminal connections with installation of secondary feeders.
5. Grout mounting channels into floor or mounting pads.

6. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.
7. Motor Data: Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:
 - a. Motor served by tag number and equipment name.
 - b. Nameplate horsepower.
 - c. Motor code letter.
 - d. Full load amperes.
 - e. Service factor.
 - f. Installed overload relay heater catalog number.

B. Circuit Breakers:

1. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.
2. Adjust to approximately 11 times motor rated current.
3. Determine motor rated current from motor nameplate following installation.

C. Overload Relay: Select and install overload relay heaters and switch settings after actual nameplate full-load current rating of motor has been determined.

3.02 MANUFACTURER'S SERVICES

- A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Job Site for minimum person-days listed below, travel time excluded:
1. 2 person-days for installation assistance, and inspection of installation.

END OF SECTION

**SECTION 26 27 26
WIRING DEVICES****PART 1 GENERAL**

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM): A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 2. Federal Specifications (FS):
 - a. W-C-596G, General Specification for Connector, Electrical, Power.
 - b. W-S-896F, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
 3. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
 - a. C62.41.2, Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits.
 - b. C62.45, Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits.
 4. National Electrical Contractors Association (NECA): 1, Standard Practice of Good Workmanship in Electrical Contracting.
 5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. FB 11, Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations.
 - c. WD 1, General Color Requirements for Wiring Devices.
 - d. WD 6, Wiring Devices – Dimensional Specifications.
 6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 7. Underwriters Laboratories Inc. (UL):
 - a. 498, Standard for Safety for Attachment Plugs and Receptacles.
 - b. 508, Standard for Safety for Industrial Control Equipment.
 - c. 943, Standard for Safety for Ground-Fault Circuit-Interruption.
 - d. 1010, Standard for Safety for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations.
 - e. 1436, Standard for Safety for Outlet Circuit Testers and Similar Indicating Devices.
 - f. 1449, Standard for Safety for Surge Protective Devices (SPD).

1.02 SUBMITTALS

- A. Action Submittals: Manufacturer's product data for wiring devices.

PART 2 PRODUCTS

2.01 SWITCHES

A. Switch, General Purpose:

1. NEMA WD 1 and FS W-S-896F.
2. Totally enclosed, ac type, with quiet tumbler switch and screw terminal.
3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contact.
4. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
5. Rating: 20 amps, 120/277 volts.
6. Automatic grounding clip and integral grounding terminal on mounting strap.
7. Special Features: Provide the following features in comparable devices where indicated:
 - a. Three-way and four-way.
8. Manufacturers and Products, Industrial Grade:
 - a. Cooper Arrow Hart; AH1220 Series.
 - b. Bryant; 4901 Series.
 - c. Hubbell; 1221 Series.
 - d. Leviton; 1221 Series.

B. Switch, Motor Rated:

1. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
2. UL 508 listed.
3. Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts.
4. Minimum General Purpose Rating: 30 amperes, 600V ac.
5. Minimum Motor Ratings:
 - a. 2 horsepower for 120V ac, single-phase, two-pole.
 - b. 3 horsepower for 240V ac, single-phase, two-pole.
 - c. 15 horsepower for 480V ac, three-phase, three-pole.
6. Screw-type terminal.
7. Manufacturers and Products:
 - a. Cooper Arrow Hart.
 - b. Hubbell Bryant: HBL78 Series.
 - c. Leviton.

2.02 RECEPTACLES

A. Receptacle, General Purpose:

1. NEMA WD 1 and FS W-C-596G.
2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body, with finger grooves in face, unless otherwise indicated.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, unless otherwise indicated.
7. Size: For 2-inch by 4-inch outlet box.
8. Special Features: Provide the following features in comparable devices where indicated:
 - a. Listed weather-resistant per NEC 406.8.
9. Industrial Grade Manufacturers and Products:
 - a. Cooper Arrow Hart; 5362 Series.
 - b. Hubbell Bryant; HBL5362 Series.
 - c. Leviton; 5362 Series.

B. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacle.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Rectangular smooth face with push-to-test and reset buttons.
4. Listed weather-resistant per NEC 406.8.
5. Feed-through Capability: 20 amps.
6. Manufacturers and Products:
 - a. Hubbell Bryant; GFTR20 Series.
 - b. Cooper Arrow Hart WRVGF20 Series.
 - c. Leviton; 7899 Series.

C. Receptacle, Special-Purpose:

1. Rating and number of poles as indicated or required for anticipated purpose.
2. Where indicated provide matching plug with cord-grip features for each special-purpose receptacle.

2.03 DEVICE PLATES

- A. Sectional type plate not permitted.
- B. Cast Metal:
 - 1. Material: Malleable ferrous metal, or copper-free aluminum, with gaskets.
 - 2. Screw: Oval-head stainless steel.
- C. Weatherproof:
 - 1. Receptacle, Weatherproof Type 1:
 - a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
 - b. Mounting Screw and Cap Spring: Stainless steel.
 - c. Manufacturers and Products:
 - 1) Crouse-Hinds; Type WLRD-1.
 - 2) Appleton; Type FSK-WRD.
 - 2. Receptacle, Weatherproof Type 2:
 - a. UL listed for wet location while in use.
 - b. Die cast metal cover.
 - c. Manufacturer and Product: TayMac; Type Multi-Mac.
 - 3. Switch:
 - a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
 - b. Mounting Screw: Stainless steel.
 - c. Manufacturer and Product: TayMac; Type TC.
- D. Sheet Steel: Formed sheet steel or Feraloy designed for installation on cast-metal box.

2.04 FINISHES

- A. Wiring device catalog numbers specified in this section do not designate device color. Unless otherwise indicated, or required by code, provide colors as specified below.
- B. Wiring Device: Gray.
- C. Special purpose devices may be manufacturer's standard color (black).

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

- A. Comply with NECA 1.
- B. Coordination with Other Trades:
 - 1. Ensure device and its box are protected. Do not place wall finish materials over device box and do not cut holes for box with router that is guided by riding against outside of box.
 - 2. Keep outlet box free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate raceway system, conductors, and cables.
 - 3. Install device box in brick or block wall such that cover plate does not cross a joint, unless otherwise indicated. Where indicated or directed to cross joint, trowel joint flush with face of wall.
 - 4. Install wiring device after wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. 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 damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted provided outlet box is large enough.
- D. Device Installation:
 - 1. Replace devices that have been in temporary use during construction or that show signs they were installed before building finishing operations were complete.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6 inches (150 mm) in length.
5. Use torque screwdriver when a torque is recommended or required by manufacturer.
6. When conductors larger than 12 AWG are installed on 15-amp or 20-amp circuits, splice 12 AWG pigtails for device connections.
7. Tighten unused terminal screws on device.
8. Device Plates:
 - a. Do not use oversized or extra deep plate.
 - b. Repair wall finishes and remount outlet box when standard device plate does not fit flush or does not cover rough wall opening.

3.02 SWITCH INSTALLATION

A. Switch, General Purpose:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switch such that toggle is in up position when switch is on.

B. Switch, Motor Rated:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position such that toggle is in up position when ON.
3. Install within sight of motor when used as disconnect switch.

C. Occupancy Sensor, Wall Switch: Install in accordance with manufacturer's instructions.

3.03 RECEPTACLE INSTALLATION

A. Duplex Receptacle:

1. Install with grounding slot up, except where horizontal mounting is shown, in which case install with neutral slot up.
2. Ground receptacle to box with grounding wire only.
3. Weatherproof Receptacle:
 - a. Install in cast metal box.
 - b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for "downstream" conventional receptacles.

5. Special-Purpose Receptacle: Install in accordance with manufacturer's instructions.

3.04 DEVICE PLATE INSTALLATION

- A. Securely fasten to wiring device; ensure tight fit to box.
- B. Flush Mounted: Install with all four edges in continuous contact with finished wall surface without use of mat or similar material. Plaster fillings will not be acceptable.
- C. Surface Mounted: Plate shall not extend beyond sides of box, unless plate has no sharp corners or edges.
- D. Install with alignment tolerance to box of 1/16 inch.
- E. Type (Unless Otherwise Shown):
 1. Exterior:
 - a. Switch: Weatherproof.
 - b. Receptacle in Damp Location: Weatherproof Type 1.
 - c. Receptacle in Wet Location: Weatherproof Type 2.
 2. Other Areas: Metal.
- F. Interior:
 1. Surface Mounted, Metal Box:
 - a. General Purpose Areas: Sheet Steel.
 - b. Process Areas: Cast.
 2. Surface Mounted, Aluminum Box:
 - a. General Purpose Areas: Stamped.
 - b. Other Areas: Cast.
 3. Receptacle Shown as Weatherproof on Drawings: Weatherproof Type 1.

3.05 IDENTIFICATION

- A. Use tape labels for identification of individual wall switches and receptacles in indoor locations.
 1. Degrease and clean device plate surface to receive tape labels.
 2. Use 3/16-inch Kroy black letters on white background, unless otherwise indicated.
 3. Identify panelboard and circuit number from which item is served on face of plate.

- B. Identify conductors with durable wire markers or tags inside outlet boxes where more than one circuit is present.

3.06 FIELD QUALITY CONTROL

- A. Perform tests and inspections, and prepare test reports.
- B. Test Instrument for 125-Volt 20-Amp Receptacle: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
- C. Using test plug, verify device and its outlet box are securely mounted.
- D. Line Voltage Range: 105 volts to 132 volts.
- E. Percent Voltage Drop under 15-Amp Load: Less than 6 percent; 6 percent or higher is not acceptable.
- F. Ground Impedance: 2 ohms, maximum.
- G. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
- H. Tests shall be diagnostic, indicating damaged conductors, high resistance at 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.

END OF SECTION

SECTION 26 29 23
LOW-VOLTAGE ADJUSTABLE FREQUENCY DRIVE SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Electronic Industries Alliance (EIA): 359-A-1, Special Colors.
2. Hydraulic Institute Standards (HIS).
3. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
 - b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
 - c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturer's Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. CP 1, Shunt Capacitors.
 - c. MG 1, Motors and Generators.
 - d. WC 57, Standard for Control, Thermocouple Extensions, and Instrumentation Cables.
5. National Fire Protection Association (NFPA): 79, Electrical Standard for Industrial Machinery.

1.02 DEFINITIONS

A. Terms that may be used in this section:

1. AFD: Adjustable frequency drive.
2. CMOS: Complementary metal oxide semiconductor.
3. CSI: Current source inverter.
4. EMU: Energy monitoring unit.
5. GTO: Gate turn-off thyristor.
6. MPR: Motor protection relay.
7. MTBF: Mean time between failure.
8. PWM: Pulse width modulation.
9. ROM: Read only memory.
10. RTD: Resistance temperature detector.
11. RTU: Remote Telemetry Unit.
12. Rated Load: Load specified for equipment.

13. Rated Speed: Nominal rated (100 percent) speed specified for equipment.
14. TDD: Total demand distortion.
15. THD: Total harmonic distortion.
16. TTL: Transistor logic.
17. VFD: Variable frequency drive (Same as AFD).

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:

1. Composite drive/motor efficiency (CE) is defined as ratio of motor shaft kW to drive input kW. AFD system minimum requirements:
 - a. At 60-Hz drive output and 100 percent load, CE equals 92 percent.
 - b. At 50-Hz drive output and 60 percent load CE equals 89 percent.
 - c. At 40-Hz drive output and 30 percent load CE equals 84 percent.
 - d. At 30-Hz drive output and 12.5 percent load CE equals 77 percent.
2. Rated Continuous Operation Capacity: Not less than 1.15 times full load current rating of driven motor, as indicated on motor nameplate, and suitable for continuous operation at continuous overload which may be imposed on motor by driven pump operating over specified speed range.
3. Furnish isolating transformers or series reactors or other devices necessary for proper system operation. Furnish necessary devices and circuits to prevent operation of one drive from adversely affecting operation of other drives supplied from same transformer or same bus.
4. When isolation transformers are used, design to meet K-factor requirements of drive(s) connected.

B. Design Requirements:

1. Drive system consisting of adjustable frequency controller, drive motor, auxiliary items, and components necessary for complete operating system.
2. Other equipment is being powered from same bus as adjustable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.
3. Furnish AFDs rated on basis of actual motor full load nameplate current rating times the service factor.
4. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using pulse-width-modulation (PWM) technique to produce adjustable frequency output.

5. System rated for continuous industrial duty and suitable for use with NEMA MG 1, Design B motors.
6. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for drive system.
7. Incoming Line Reactor: Design to minimize harmonic distortion on incoming power feeder.

1.04 SUBMITTALS

A. Action Submittals:

1. Overall drive system operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, 100, and 110 percent of rated speed.
2. AFD output pulse maximum peak voltage, pulse rise time, and pulse rate of rise including justification for proposed deviation from specified values. Include motor manufacturer's certification motor insulation will withstand long-term overvoltages caused at motor terminals due to specified output pulse data or proposed deviation from this data.
3. Data on shelf life of "dc link" capacitor.
4. Complete system rating, including nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.
5. Complete adjustable frequency controller rating coordinated with motor full load nameplate current rating; list controller special features being supplied.
6. Controller, reactor, dimensional drawings; information on size and location of space for incoming and outgoing conduit.
7. Maximum heat dissipation from enclosure.
8. Should separate enclosures and equipment be necessary for line reactor elements, provide complete dimensional information including location of space for incoming and outgoing conduit, weight, maximum heat loss, and minimum current carrying capacity and recommended wire size for required interconnecting circuits.
9. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.
10. Complete system operating description.
11. Complete system schematic (elementary) wiring diagrams.
12. Complete system interconnection diagrams between controller, drive motor, field devices, and related components or controls external to system, including wire numbers and terminal board point identification.
13. One-line diagram of system, including component ratings.
14. Description of diagnostic features being provided.

- 15. Descriptive literature for control devices such as relays and timers.
- 16. Itemized bill-of-materials listing system components.

B. Informational Submittals:

- 1. Statement of Supplier qualifications.
- 2. Special shipping, storage and protection, and handling instructions.
- 3. Manufacturer’s printed installation instructions.
- 4. Factory functional test reports.
- 5. Field test reports.
- 6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
- 7. Provide a table of all AFD parameters for each VFD as part of the O&M manual.
- 8. Submit ASD file with all the AFD parameters on a CD.
- 9. Operation and Maintenance Data: As specified in Section 01 76 00, Operating and Maintenance Information.
- 10. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.

1.05 QUALITY ASSURANCE

- A. Supplier: Minimum 5 years’ experience in furnishing similar size and type adjustable frequency, controlled speed, drive systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Components and accessories specified in this section shall be products of:
 - 1. Eaton Cutler Hammer.
 - 2. Danfoss.
 - 3. Siemens
 - 4. Allen-Bradley.
 - 5. ABB.
 - 6. Toshiba.
 - 7. Square D.

2.02 SERVICE CONDITIONS

- A. Ambient Operating Temperature: 32 degrees F to 104 degrees F.
- B. Storage Temperature: Minus 40 degrees F to 158 degrees F.
- C. Humidity: 0 percent to 95 percent relative (noncondensing).

- D. Altitude: 0 foot to 3,300 feet.
- E. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

2.03 COMPONENTS

A. Drive Units:

1. Incorporate switching power supply operating from dc bus, to produce PWM output waveform simulating sine wave and providing power loss ride through of 2 milliseconds at full load, full speed.
2. Current-limiting semiconductor fuses for protection of internal power semiconductors.
3. Employ diode bridge rectifier providing constant displacement power factor of 0.95 minimum at all operating speeds and loads.
4. Use transistors for output section, providing a minimum 97 percent drive efficiency at full speed, full load.
5. Employ dc power discharge circuit so that after removal of input power dc link capacitor voltage level will decay below 50 volts dc within 1 minute after de-energizing following NEMA CP 1 and NFPA 79. Design dc link capacitor for a MTBF of 5 years.
6. Operate with open circuited output.
7. Input Voltage: 480V ac plus or minus 10 percent.
8. Output Voltage: 0 to 480 volts, three-phase, 0 to 66-Hz, minimum.
9. Maximum peak voltage of PWM AFD output pulse of 1,000 volts, with pulse rise time of not less than 2 microseconds, and maximum rate of rise of 500 volts per microsecond. Maximum frequency of PWM AFD output pulse (carrier) frequency of 3,000-Hz. Should magnitudes of these characteristics be more stressful to motor insulation than specified values, furnish insulation systems on motors suitable for proposed values.
10. Motor Audible Noise Level: When operating throughout speed range of PWM AFD, no more than 3 dBA above that designated in NEMA MG 1 for same motor operated at constant speed with a 60-Hz supply voltage.
11. Short-Time Overload Capacity: 125 percent of rated load in rms current for 1 minute following full load, full speed operation.
12. Equipment Short-Circuit Rating: Suitable for connection to system with maximum source three-phase, bolted fault, short-circuit available of 42,000 amps rms symmetrical at 480 volts.
13. Furnish drives with output current-limiting reactors mounted within equipment enclosure.
14. Diagnostics: Comprehensive for drive adjustment and troubleshooting:
 - a. Memory battery backup; 100-hour minimum during power loss.
 - b. Status messages will not stop drive from running but will prevent it from starting.

- c. Fault Condition Messages and History: First fault protection function to be activated, ability to store six successive fault occurrences in order. Minimum faults numerically:
 - 1) Overcurrent (time and instantaneous).
 - 2) Overvoltage.
 - 3) Undervoltage (dc and ac).
 - 4) Overtemperature (drive, motor windings, motor bearing, pump bearing).
 - 5) Serial communication fault.
 - 6) Short-circuit/ground fault (motor and drive).
 - 7) Motor stalled.
 - 8) Semiconductor fault.
 - 9) Microprocessor fault.
 - 10) Single-phase voltage condition.
- 15. Drive Protection:
 - a. Fast-acting semiconductor fuses.
 - b. Overcurrent, instantaneous overcurrent trip.
 - c. Dc undervoltage protection, 70 percent dropout.
 - d. Dc overvoltage protection, 130 percent pickup.
 - e. Overtemperature, drive, inverter, converter, and dc link components.
 - f. Overtemperature, motor, and pump.
 - g. Single-phase protection.
 - h. Reset overcurrent protection (manual or automatic reset).
 - i. Active current limit/torque limit protection.
 - j. Semiconductor fault protection.
 - k. Short-circuit/ground fault protection.
 - l. Serial communication fault protection.
 - m. Microprocessor fault.
 - n. Surge protection for transient overvoltage (6,000 volts, 80 joule surge, tested per IEEE C62.41).
 - o. Visual display of specific fault conditions.
- 16. Operational Features:
 - a. Use manufacturer's standard unless otherwise indicated.
 - b. Sustained power loss.
 - c. Momentary power loss.
 - d. Power interruption.
 - e. Power loss ride through (0.1 second).
 - f. Start on the fly.
 - g. Electronic motor overload protection.
 - h. Stall protection.
 - i. Slip compensation.
 - j. Automatic restart after power return (ability to enable/disable function).

- k. Critical frequency lockout (three selectable points minimum, by 1.5-Hz steps in 10-Hz bands, to prevent resonance of system).
 - l. Drive maintenance system software for complete programming and diagnostics.
 - m. Ground fault protection, drive, and motor.
 - n. Operate with no motor connected to output terminals.
- B. Rectifier: Three-phase 18-pulse full wave diode bridge rectifier to provide constant dc voltage to drive's dc bus.
- C. Furnish series choke and capacitors on dc bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.
- D. Controller: Microprocessor-controller PWM inverter to convert to dc voltage to variable voltage, adjustable frequency, three-phase ac output. Output voltage shall vary proportionally with frequency to maintain constant ratio of volts to hertz up to 60-Hz; above 60-Hz, voltage shall remain constant with drive operating in constant horsepower output mode.
- E. Enclosure:
1. NEMA 250, Type 1, gasketed, freestanding, enclosure for mounting against wall, completely front accessible, and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure not to exceed dimensions shown on Drawings.
 2. Cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton, alphanumeric keypad and display, and operator's controls. Components and controls specified in Section 26 05 04, Basic Electrical Materials and Methods.
 3. Wire drive from below for power and control wiring.
 4. Size forced-ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for drive when operating at maximum capacity. Furnish filters on ventilation intakes.
 5. Wiring:
 - a. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding.
 - b. Label each terminal for permanent identification of leads.
 - c. Identify each wire at each end with imprinted Mylar adhesive-back wire markers.

- d. Incorporate in as-installed wiring diagrams for wire and terminal numbers shown.
 - e. Wiring across door hinge, use 19-strand, NEMA WC 57 Class C stranding looped for proper twist rather than bending at hinge.
 - f. Wire connections internal to panels by crimp-on terminal types.
 - g. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring.
 - h. Multipoint plug receptacles for control wiring crossing equipment shipping splits.
6. Selector switches, indicating lights, potentiometers, instruments, protective devices, and major system components identified by means of mechanically attached, engraved, laminated nameplates.

F. Operator Interface:

1. Controls: Mount drive local control on front door of enclosure and include controls as shown on Drawings and as noted below:
 - a. Start (when switch is in "Local On" mode). Speed shall be determined by local potentiometer.
 - b. Stop (when in "Local On" mode).
 - c. Parameter mode selection (recall programmed parameters).
 - d. LOCAL ON/LOCAL AUTO/REMOTE REMOTE AUTO selector switch (in remote auto, furnish for remote RUN command digital input and speed increase/decrease via remote 4 mA to 20 mA analog signal).
 - e. Fault reset, manual for faults, except loss of ac voltage which is automatic upon return.
 - f. LOCAL AUTO: When selector switch is local auto the AFD shall run at a preset speed when local auto run input is closed. AFD shall stop when input is open.
 - g. Parameter lock, password or key switch lockout of changes to parameters.
 - h. Start disable, key switch or programmed code.
 - i. Provide local potentiometer speed control as shown on Drawings.
 - j. Provide indicating lights and reset buttons as shown on Drawings.
2. 120 volts, single-phase, 60-Hz circuits for control power and operator controls from internal control power transformer. Furnish power for motor space heaters rated 120 volts.
3. Arrange component and circuit such that failure of a single component cannot cause cascading failure(s) of other component(s).
4. Alphanumeric Display: During normal operation and routine test, the following parameters shall be available:
 - a. Motor current (percent of drive rated current).
 - b. Output frequency (Hertz).
 - c. Output voltage.

- d. Running time.
 - e. Local/remote indicator.
 - f. Status of digital inputs and outputs.
 - g. Analog input and output values.
 - h. Output motor current per leg.
 - i. All test points.
5. Adjustable Parameters: Set drive operating parameters and indicate in numeric form. Potentiometers may not be used for parameter adjustment. Minimum setup parameters available:
- a. Frequency range, minimum, maximum.
 - b. Adjustable acceleration/deceleration rate.
 - c. Volts per Hertz (field weakening point).
 - d. Active current limit/torque limit, 0 percent to 140 percent of drive rating.
 - e. Adjustable voltage boost (IR compensation).
 - f. Preset speed (adjustable, preset operating point).
 - g. Provision for adjustment of minimum and maximum pump speed to be furnished as function of 4 mA to 20 mA remote speed signal.

G. Signal Interface:

1. Digital Input: Accept digital inputs as shown on Drawings.
2. Digital Output: Furnish discrete output dry contact closures rated 5 amps at 120 volts ac as shown on Drawings.
3. Analog Input: When ON/OFF/REMOTE switch is in REMOTE, control drive speed from remote 4 mA to 20 mA dc signal.
 - a. Make provisions for adjustment of minimum and maximum motor speed which shall result from this signal.
 - b. Factory set this adjustment to comply with operating speed range designated in driven equipment specifications.
 - c. Frequency resolution shall be 0.1 percent of base speed.
4. Analog Output: Furnish one 4 mA to 20 mA dc signals for actual frequency, actual load.

H. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.
3. Anchor Bolts: Sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Anchor bolt material shall be in accordance with Area Classification and Material Selection Table on Drawings.

2.04 FACTORY FINISHING

A. Enclosure:

1. Primer: One coat of rust-inhibiting coating.
2. Finish:
 - a. Interior: One coat white enamel.
 - b. Exterior: Light gray.
3. Manufacturer's standard baked enamel finish.

2.05 SOURCE QUALITY CONTROL

- A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.
- B. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's printed instructions.

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each controller.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
3. Vibration Test:
 - a. Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation shall not develop amplitudes of vibration exceeding limits recommended by HIS.
 - b. Where loads and drives are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
4. Record test data for report.

B. Performance Test:

1. Conduct on each controller.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous 12-hour period without malfunction.
4. Demonstrate performance by operating continuous period while varying application load, as input conditions allow, to verify system performance.

3.03 MANUFACTURERS' SERVICES

- A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
1. 1 person-day for installation assistance and inspection.
 2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
 3. 1 person-day for prestartup classroom or Site training.
 4. 2 person-days for facility startup.
 5. 1 person-day for post-startup training of Owner's personnel.
- B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 75 00, Testing, Equipment Startup, and Commissioning.

END OF SECTION

SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C37.90.1, Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
2. National Electrical Manufacturers Association (NEMA):
 - a. ICS 1, General Standards for Industrial Control and Systems: General Requirements.
 - b. ICS 2, Industrial Control and Systems Controllers, Contactors, and Overload Relays not more than 2000 volts ac or 750 volts ac.
 - c. ICS 6, Industrial Control And Systems: Enclosures 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
4. Underwriters Laboratories, Inc. (UL): 1008, Transfer Switch Equipment.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Dimensional drawings.
3. Control diagrams.
4. Conduit entrance locations.
5. Equipment ratings.
6. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Factory test reports.
4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.

5. Operation and Maintenance Data: As specified in Section 01 76 00, Operating and Maintenance Information.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Eaton.
- B. ASCO.
- C. Russelectric.

2.02 GENERAL

- A. Transfer switch to be product of a single manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.
- B. In accordance with applicable standards of NFPA 70, NEMA ICS 1, NEMA ICS 2, NEMA ICS 6, IEEE C37.90.1, and UL 1008.
- C. Transfer switch shall be a bypass isolation type consisting of two inherently double-throw power switch unit with interconnected control module. Bypass switch shall have the ability to carry all of the rated current when transfer switch is removed for maintenance or replacement.
- D. Transfer switch and bypass switch shall both be draw-out construction in a front access structure.
- E. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, discharge lamp loads, and tungsten-filament lamp loads.

- F. Suitable for 480 volts, three-phase, three-wire, grounded-wye electrical service having an available short circuit current at line terminals of 65,000 amperes rms symmetrical.
- G. Transfer Switch and Bypass Switch Rating: As shown on Drawings in nonventilated enclosure.
- H. Current carrying capacity of arcing contacts shall not be used to determine the transfer switch rating.
- I. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- J. Operating Conditions:
 - 1. Ambient Temperature: Maximum 40 degrees C.
 - 2. Equipment to be fully rated without any derating for operating conditions listed above.

2.03 ENCLOSURE

- A. Type: Nonventilated NEMA 250, Type 1 with enclosure grounding terminal.
- B. Dead front, front accessible floor mounted cabinet with 14-gauge welded steel construction.
- C. Enclosure shall have house bypass contactors and ATS contactors in separate compartments. Each compartment shall have its own separate padlockable door.
- D. Finish: Baked enamel applied over rust-inhibiting, phosphated base coating.
 - 1. Exterior and Interior Color: Provide gray finish as approved by Owner.
 - 2. Unpainted Metal Parts: Plated for corrosion resistance.

2.04 TRANSFER AND BYPASS SWITCHES

- A. Type: Electrically operated, mechanically held, double-throw contactors.
- B. Momentarily energized, single-electrically operated mechanism energized from source to which load is to be transferred.
- C. Locking mechanism to maintain constant contact pressure.
- D. Switch shall have a time delay in neutral position to ensure only one of two possible switch positions.

- E. Silver alloy contacts protected by arcing contacts.
- F. Main and arcing contacts visible when door is open and barrier covers removed.
- G. Both the transfer switch and the bypass switch contactors shall be interlocked to prevent cross connecting the two power sources.
- H. The bypass isolation transfer switch shall have three positions: CONNECTED, ISOLATED, and REMOVED. In the CONNECTED position, ATS is racked-in and is being actively controlled by the controller. In the ISOLATED position, the ATS is connected to control power only and may be electrically operated for test purposes. In the REMOVED position, the ATS has been disconnected from the main bus and control power and the transfer switch may be safely removed for inspection or replacement.
- I. The ATS shall be capable of being racked-out with the enclosure door closed. An indicating light shall be mounted on the door to indicate when the ATS is ISOLATED from the power and when the ATS is in the REMOVED position. An interlock shall be provided to prevent the ATS from being racked out while the transfer switch is still powering the load.
- J. The bypass switch shall be interlocked to prevent connecting or disconnecting the contactor from the bus with the contact closed.
- K. Manual operating handle for transfer in either direction in the ISOLATED or REMOVED position.
- L. Internal control wire connections made with ring or spade type terminals, lock washers, and sleeve type marking labels.

2.05 CONTROL MODULE

- A. Completely enclosed and mounted integral to the transfer switch enclosure.
- B. Microprocessor for sensing and logic control with inherent digital communications capability.
- C. Plug-in, industrial grade interfacing relays with dust covers.
- D. Connected to transfer switch by wiring harness having keyed disconnect plug.
- E. Plug-in printed circuit boards for sensing and control logic.
- F. The transfer to bypass shall be accomplished by operation of a single selector switch. The selector switch shall have an AUTO and BYPASS position. Transfer to bypass shall not interrupt power to the load.

- G. Adjustable solid state undervoltage sensors for all three phases of normal and for one phase of standby source:
 - 1. Pickup 85 to 100 percent nominal.
 - 2. Dropout 75 to 98 percent of pickup setting.
- H. Adjustable frequency sensors for standby source:
 - 1. Pickup 90 to 100 percent nominal.
 - 2. Dropout 87 to 89 percent of pickup setting.
- I. Control module with adjustable time delays:
 - 1. 0.5- to 6-second engine start delay.
 - 2. 0- to 5-minute load transfer to emergency delay.
 - 3. 0- to 30-minute retransfer to normal delay.
 - 4. 0- to 30-minute unload running time delay.
 - 5. Switch to bypass any of the above time delays during testing.
- J. Form-C start contacts, rated 10 amperes, 32-volt dc, for two-wire engine control, wired to terminal block.
- K. Exerciser, adjustable in 15-minute increments, 7-day dial clock, complete with door mounted NO LOAD and LOAD selector switch.
- L. Adjustable 0 to 5 minutes time delay relay for engine starting signal.

2.06 INDICATORS

- A. Type: Manufacturer's standard green lens to indicate switch position for normal power source.
- B. Red lens to indicate switch position for standby power source.
- C. White lens to indicate normal power source is available within parameters established by pickup and dropout settings.
- D. Amber lens to indicate standby power source is available within parameters established by pickup and dropout settings.
- E. Provide one normally open and one normally closed, 5 amperes, 120-volt contact for the following status conditions:
 - 1. Transfer Switch is in NORMAL position.
 - 2. Transfer Switch is in STANDBY position.
 - 3. Loss of NORMAL power.

2.07 FACTORY TESTS

- A. Test to Ensure Correct:
 - 1. Operation of individual components.
 - 2. Sequence of operation.
 - 3. Transfer time, voltage, frequency, and time delay settings.
- B. Dielectric strength test per NEMA ICS 1.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure enclosure to floor using anchor bolts of sufficient size and number adequate for specified seismic conditions.

END OF SECTION

SECTION 26 43 00
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUBMITTALS

- A. Submit product data on each SPD type, indicating component values, part numbers, and conductor sizes. Include dimensional drawing for each, showing mounting arrangements.
- B. Submit manufacturer's UL certified test data and nameplate data for each SPD.
- C. Submit electrical single-line diagram showing location of each SPD.

1.02 QUALITY ASSURANCE

- A. UL Compliance and Labeling:
 - 1. For power and signal circuits, SPDs shall comply with UL 1449 and complimentary listed to UL 1283 as an electromagnetic interference filter. Provide units that are listed and labeled by UL.
 - 2. For telephone circuit protection, SPDs shall comply with UL 497A.
- B. ANSI Compliance: Use SPDs in compliance with the recommendations of IEEE C62.41.1, IEEE C62.41.2, and IEEE C62.45.

PART 2 PRODUCTS

2.01 GENERAL

- A. All SPDs for power circuits, provided under this section, shall be the product of a single manufacturer.
- B. SPDs shall be capable of performance at ambient temperatures between minus 40 degrees C and 60 degrees C, at relative humidity ranging from 0 percent to 95 percent, and at altitudes ranging from sea level to 12,000 feet.
- C. SPDs shall be fused to disconnect the device from the electrical source should the SPD fail. The fusing shall allow full surge handling capabilities and to afford safety protection from thermal overloads and short circuits.

- D. Design SPDs for the specific type and voltage of the electrical service. Single-phase and three-phase wye-configured systems shall have L-N, L-G, and N-G protection. Grounded delta-configured systems shall have L-L and L-G protection.
- E. Power Filter: The SPD shall include a high frequency extended range power filter complimentary listed to UL 1283 as an electromagnetic interference filter.

2.02 MANUFACTURER

- A. Eaton.
- B. Innovative Technology, VanGuard Series.
- C. Advanced Protection Technologies, Inc.
- D. General Electric.

2.03 MAIN DISTRIBUTION SPD

- A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category C.
- B. Surge current capacity shall be not less than the following:
 - 1. L-N Capacity: 200 kA.
 - 2. L-G Capacity: 120 kA.
 - 3. N-G Capacity: 120 kA.
- C. SPD housing shall be in an enclosure that has the same NEMA rating as the equipment it protects and painted to match.
- D. UL 1449 maximum suppression voltage shall not be more than:

System Voltage	Phase	L-L or L-N Suppression Voltage
120	1	400
208Y/120	3	400
240	3	800
480Y/277	3	800

2.04 PANELBOARD SPD

- A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location Category B.
- B. Surge current capacity shall be not less than the following:
1. L-L Capacity: 80 kA.
 2. L-N Capacity: 80 kA.
 3. L-G Capacity: 80 kA.
 4. N-G Capacity: 80 kA.
- C. SPD shall be in an enclosure that has the same NEMA rating as the panel it protects or the SPD may be integral to a panelboard.
- D. UL 1449 maximum clamp voltage shall not be more than:

System Voltage	Phase	L-L or L-N Clamp Voltage
120	1	400
208Y/120	3	400
240	3	800
480Y/277	3	800

2.05 ANNUNCIATION

- A. Provide unit or separately mounted LED-type indication lights to show the normal and failed status of each module. Provide one normally open and one normally closed contacts which operate when the unit fails.

2.06 SURGE COUNTER

- A. Provide each SPD rated above 100 kA with a counter displaying the number of voltage transients that have occurred on the unit input. The counter shall be battery backed and retain the count through system power outages.

2.07 PAIRED CABLE DATA LINE INTERIOR SPD

- A. Provide units meeting IEEE C62.41, Location Category A.
- B. Use bi-polar 1,500-watt silicon avalanche diodes between the protected conductor and earth ground.

- C. Provide units with a maximum single impulse current rating of 80 amperes (10 by 1,000 microsecond-waveform).
- D. Breakdown voltage shall not exceed 36 volts.

2.08 PAIRED CABLE DATA LINE EXTERIOR SPD

- A. Provide units meeting IEEE C62.41, Location Category A.
- B. SPDs shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally.
- C. SPDs shall meet or exceed the following criteria:
 - 1. Maximum single impulse current rating of 10,000 amperes (8 by 20 microsecond-waveform).
 - 2. Pulse Life Rating: 3,000 amperes (8 by 20 microsecond-waveform): 2,000 occurrences.
 - 3. Maximum clamping voltage at 10,000 amperes (8 by 20 microsecond current waveform), shall not exceed the peak of the normal applied signal voltage by 200 percent.

PART 3 EXECUTION

3.01 APPLICATION REQUIREMENTS

- A. Install SPD when indicated on the Drawings and:
 - 1. Panelboard SPD in each panelboard unless otherwise indicated.
- B. Electronic Equipment Paired Cable Conductors: Install data line SPDs at each analog input and output of CCM enclosure.
 - 1. Use secondary protectors on lines that do not exit the structure.
 - 2. Use primary protectors on lines that exit and enter the structure.

3.02 GENERAL INSTALLATION REQUIREMENTS

- A. Install SPDs according to manufacturer's recommendations.
- B. Install SPDs directly to the cabinet which houses the circuit to be protected so that the SPD leads are straight and short, with all conductors laced, running directly to the point of connection within the panel, without loops or bends. If bends are unavoidable, no bend may exceed 90 degrees and bending radius may not be less than 6 inches.

- C. Connecting wires shall be as short as possible with gently twisted conductors, tied together, to prevent separation. Connecting wires shall not exceed 24 inches in length at any point.
- D. Field installed conductors shall be the same as specified for building wire, not smaller than No. 8 AWG and not larger than No. 4 AWG. Device leads shall not be longer than the length recommended by the manufacturer, unless specifically reviewed and approved by the manufacturer.
- E. Provide dedicated disconnecting means for SPDs installed at main service entrance location, switchgear, and motor control centers. Provide dedicated 30-60-ampere circuit breakers (size dependent upon wire size used) with number of poles as required, as disconnecting means for SPDs installed at panelboards. The interrupting capacity of the circuit breakers shall be that specified for the other breakers at that location.

END OF SECTION

**SECTION 26 50 00
LIGHTING****PART 1 GENERAL**

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Canadian Standards Association (CSA).
2. Certified Ballast Manufacturer (CBM).
3. Federal Communications Commission (FCC).
4. Illuminating Engineering Society of North America (IESNA).
5. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
6. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
7. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC) – Softbound Version.
8. Underwriters Laboratories, Inc. (UL):
 - a. 595, Marine-Type Electric Lighting Fixtures.
 - b. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
 - c. 924, Emergency Lighting and Power Equipment.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Interior Luminaires:
 - 1) Catalog data sheets and pictures.
 - 2) Photometrics.
 - 3) Mounting or suspension details.
 - b. Lamps:
 - 1) Voltages.
 - 2) Colors.
 - 3) Approximate life (in hours).
 - 4) Approximate initial lumens.
 - 5) Lamp type and base.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 LUMINAIRES

- A. Specific requirements relative to execution of the Work of this section are located in Luminaire Schedule on Drawings.
- B. LED luminaires, color as indicated in Luminaire Schedule.
 1. Manufacturers:
 - a. Lithonia Lighting Company.
 - b. Cooper Lighting.
 - c. General Electric Co.
 - d. Osram Sylvania.
 - e. Phillips Lighting Company.
- C. Feed-through type.
- D. Wire Leads: Minimum 18 AWG.
- E. Component Access: Accessible and replaceable without removing luminaire from ceiling.
- F. Exterior Luminaires: Refer to Section 26 56 00, Exterior Lighting, for requirements.

PART 3 EXECUTION**3.01 LUMINAIRES****A. General:**

1. Install in accordance with manufacturer's recommendations.
2. Provide proper hangers, pendants, and canopies as necessary for complete installation and meeting specified seismic requirements.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building required to safely mount luminaires.
4. Install plumb and level.
5. Install each luminaire outlet box with galvanized stud.

B. Mounting:

1. General: Mounting, fastening, and environmental conditions shall be coordinated with Section 26 05 02, Basic Electrical Requirements.
2. Wall Mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.

C. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

1. Attach fixtures to steel framing channel, unless otherwise noted.
2. Fixture Suspension: Provide 1/4-inch threaded steel hanger rods. Scissor type hangers not permitted.
3. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.
4. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.

D. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.**3.02 LIGHTING CONTROL**

- A. Lighting control as shown on Drawings.

3.03 EMERGENCY LIGHTING UNIT

- A. Install in accordance with manufacturer's recommendations.
- B. Provide permanent circuit connections with conduit and wire.

- C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.
- D. Provide separate circuit wiring to luminaire.

3.04 CLEANING

- A. Remove labels and markings, except UL listing mark.
- B. Wipe luminaires inside and out to remove construction dust.
- C. Clean luminaire plastic lenses with antistatic cleaners only.
- D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.
- E. Replace defective lamps and LED luminaires at time of Substantial Completion.

END OF SECTION

SECTION 26 56 00
EXTERIOR LIGHTING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - c. A572/A572A, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
 - d. A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel, with 50 ksi [345 MPa] Minimum Yield Point to 4-in. [100-mm] Thick.
 - e. A595/A595M, Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use.
 - f. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - g. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 - h. D6576, Standard Specification for Flexible Cellular Rubber Chemically Blown.
 - i. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
 2. American Wood Protection Association (AWPA): M6, Brands Used on Forest Products.
 3. Illuminating Engineering Society of North America (IESNA): HB-9, Lighting Handbook.
 4. The Institute of Electrical and Electronics Engineers, Inc. (IEEE): C2, National Electrical Safety Code.
 5. Military Specification (MIL): DTL-83420M, Wire Rope, Flexible, for Aircraft Control, General Specification for.
 6. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. ICS 6, Industrial Control and Systems: Enclosures.
 7. National Energy Policy Act.

8. National Fire Protection Association (NFPA): 70, National Electrical Code.
9. Rural Utilities Service (RUS): 1728F-700, Specification for Wood Poles, Stubs and Anchor Logs.
10. Underwriters Laboratories, Inc. (UL):
 - a. 595, Standard for Safety Marine-Type Electric Lighting Fixtures.
 - b. 844, Standard for Luminaires for Use in Hazardous (Classified) Locations.
11. U.S. Environmental Protection Agency and U.S. Department of Energy: Energy Star.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Exterior Luminaires:
 - 1) Catalog data sheets and pictures.
 - 2) Photometrics.
 - 3) Fastening details to wall or pole.
 - 4) For light poles, submit wind loading, complete dimensions, and finish.
 - b. Lamps:
 - 1) Voltages.
 - 2) Approximate life (in hours).
 - 3) Approximate initial lumens.
 - 4) Lamp type and base.
 - 5) Colors.
 - c. Photocells:
 - 1) Voltage, and power consumption.
 - 2) Capacity.
 - 3) Contacts and time delay.
 - 4) Operating levels.
 - 5) Enclosure type and dimensions.
 - 6) Temperature range.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Aluminum Poles:

1. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.
2. Do not store poles on ground.
3. Support poles so they are at least 1 foot above ground level and growing vegetation.
4. Do not remove factory-applied pole wrappings until just before installing pole.
5. Ship poles with bolt circle template, base cover, handhold cover, and shaft cap or tenon.

PART 2 PRODUCTS

2.01 LUMINAIRES

A. General:

1. Specific requirements relative to the Work of this section are located in Luminaire Schedule on Drawings.
2. Component Access: Accessible and replaceable without removing luminaire from its mounting.

B. Exterior Installations:

1. UL Labeled: "SUITABLE FOR WET LOCATIONS."
2. When factory-installed photo cells are provided, entire assembly shall have UL label.

C. LED luminaires, color as indicated in Luminaire Schedule.

1. Manufacturers:
 - a. Lithonia Lighting Company.
 - b. Cooper Lighting.
 - c. General Electric Company.
 - d. Osram Sylvania.
 - e. Phillips Lighting Company.

2.02 PHOTOCELL SWITCH

A. Features:

1. Automatic ON/OFF switching photo control.
2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
3. Setting: ON at dusk and OFF at dawn.
4. Time delay feature to prevent false switching.
5. Field adjustable to control operating levels.
6. Manufacturers:
 - a. Tork.
 - b. Paragon Electric Company.

2.03 IN-LINE FUSE HOLDER AND FUSE

A. Fuse Holder:

1. General: Waterproof, of corrosion-resistant material.
2. Rating: 600 volts.

B. Fuse:

1. General: Midget, dual element.
2. Rating: 5-amp, voltage as required by application.

C. Manufacturer: Methods Electronics Inc. Network, Buss Div.

2.04 POLES

A. General:

1. Design for wind load as specified in Section 01 61 00, Common Product Requirements, while supporting luminaires and other appurtenances. The effective projected areas (EPA) of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole.
2. Poles 40 feet and shorter shall be one piece construction.
3. Pole Height: As indicated on Luminaire Schedule.
4. Handhole:
 - a. Poles shall have oval-shaped handhole having a minimum clear opening of 2.5 inches by 5 inches.
 - b. Cover shall be secured by stainless steel captive screws.
 - c. Metal poles shall have internal grounding connection accessible from handhole near bottom of each pole.
5. Scratched, stained, chipped, or dented poles shall not be installed.

B. Aluminum Poles:

1. Manufactured of corrosion-resistant aluminum alloys. Seamless extruded or spun seamless type with minimum 0.125-inch wall thickness.
2. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
3. Shaft Top: Fitted with cap.
4. Base:
 - a. Anchor bolt mounted and machined to receive lower end of shaft.
 - b. Joint between shaft and base shall be welded.
 - c. Base cover shall be cast aluminum alloy.
 - d. Hardware, except anchor bolts, shall be either anodized aluminum alloy or stainless steel.
 - e. Handhole.
5. Provide pole cast-in-place foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end.
6. Provide base covers to match pole and galvanized nuts and washers for anchor bolts.
7. Finish: Pole and brackets shall have dark bronze finish to match fixture.

2.05 BRACKETS AND SUPPORTS**A. Features:**

1. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical.
2. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height indicated.
3. Mount brackets not less than 24 feet above street.
4. Special mountings or brackets shall be as indicated on Drawings and shall be of metal which will not promote galvanic reaction with luminaire head.

2.06 POLE FOUNDATIONS

- A. Anchor Bolts: Steel rod having a minimum yield strength of 50,000 psi; the top 12 inches of the rod shall be galvanized.
- B. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 EQUIPMENT IDENTIFICATION

- A. Manufacturer's Nameplate: Each item of equipment shall have a nameplate bearing manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; nameplate of distributing agent will not be acceptable.
- B. Markings shall be clear and located to be readily visible to service personnel.

2.08 FACTORY FINISH

- A. Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Electrical installations shall conform to IEEE C2 and requirements specified herein.
- B. Pole Setting:
 - 1. Depth shall be as indicated on Drawings or footing detail.
 - 2. Poles in straight runs shall be in a straight line.
 - 3. Setting Depth: As shown in Design Details.
 - 4. Soil Setting: Depths shall apply where pole holes are in soil, sand, or gravel or any combination of these.
 - 5. Setting on Sloping Ground: On sloping ground, measure depth of hole from low side of hole.
 - 6. Backfill: Tamp pole backfill for the full depth of hole and mound excess fill around pole.
 - 7. Dig holes large enough to permit the proper use of tampers to the full depth of the hole.
 - 8. Place backfill in the hole in 6-inch maximum layers and thoroughly tamp.
 - 9. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.
- C. Aluminum Poles: Install according to pole manufacturer's instructions.
 - 1. Provide cast-in-place concrete base.
 - 2. Provide branch circuit in-line fuses in pole base handhole.
- D. Photocell Switch Aiming: Mount and aim switch according to manufacturer's recommendations.

- E. Grounding: Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, Grounding and Bonding for Electrical Systems. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.02 FIELD FINISHES

- A. Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

- A. Upon completion of installation, verify equipment is properly installed, connected, and adjusted. Conduct an operating test to show equipment operates in accordance with the requirements of this section.
- B. Coordinate lighting and controls installation and testing with commissioning as specified in Section 01 75 00, Testing, Equipment Startup, and Commissioning.

3.04 CLEANING

- A. Remove labels and markings, except UL listing mark.
- B. Wipe luminaries inside and out to remove construction dust.
- C. Clean luminaire plastic lenses with antistatic cleaners only.
- D. Touchup painted surfaces of luminaries and poles with matching paint ordered from manufacturer.
- E. Replace defective lamps and LED luminaires at time of Substantial Completion.

END OF SECTION

**SECTION 31 23 19.01
DEWATERING****PART 1 GENERAL****1.01 AVAILABLE REPORTS**

- A. The following reports are provided to the Contractor and shall be used in preparing the dewatering design:
1. Strata, Inc., 2014. *Geotechnical Engineering Evaluation, Nampa Wastewater Treatment Plant Upgrades, Nampa, Idaho*. Prepared for City of Nampa, c/o Brown and Caldwell. September 8.
 2. Strata, Inc., 2007. *Geotechnical Engineering Evaluation, New Digester, Nampa Wastewater Treatment Facility, Nampa, Idaho*. Prepared for MWH Americas. November 28.
 3. Strata, Inc., 2005. *Geotechnical Engineering Evaluation, Proposed Primary Clarifier No. 3, Nampa Waste Water Treatment Facility, Nampa, Idaho*. Prepared for MWH Global. December 6.
 4. Strata, Inc., 2004. *Geotechnical Engineering Evaluation, Proposed Clarifier and RAS Pump Station, Nampa Wastewater Treatment Facility, Nampa, Idaho*. Prepared for MWH Global. May 18.
- B. If the Contractor anticipates additional information is required to prepare the design, the Contractor is responsible for obtaining the information at no additional cost to the Owner.

1.02 SUBMITTALS**A. QUALIFICATIONS**

1. The Contractor shall hire a qualified dewatering subcontractor with experience and expertise in construction dewatering. Alternately, the Contractor may self-perform the construction dewatering if the Contractor is able to demonstrate to the Engineer's satisfaction that the Contractor has the specified experience and expertise in construction dewatering.
2. The dewatering subcontractor shall have a minimum of 10 years of construction dewatering experience with a minimum of three projects that required dewatering and depressurizing of artesian conditions.
3. The dewatering subcontractor shall retain the services of a Dewatering Engineer. The Dewatering Engineer shall be an employee of or a subconsultant to the dewatering subcontractor. The Dewatering Engineer shall be a Professional Engineer registered in the State of Idaho, and shall have at least 5 years of experience in the design and

construction of dewatering systems. The experience shall be within the last 10 years and shall include experience with artesian conditions. The Dewatering Engineer shall have experience in the methods the dewatering subcontractor proposes to use. A summary of the Dewatering Engineer's experience shall be provided to the Engineer prior to the start of work.

B. Informational Submittals:

1. Dewatering Subcontractor Qualifications.
2. Dewatering Engineer Qualifications.
3. Dewatering Plan designed and stamped by the Dewatering Engineer.
4. Well permits for all wells and piezometers that are proposed in the Dewatering Plan.
5. Discharge permits.
6. Water Level Elevations Observed in Observation Wells and Piezometers: Submit same day measured.
7. Settlement Benchmark Elevations: Submit weekly record.
8. Daily Flow Monitoring Records: Submit weekly.
9. Daily Dewatering Grab Sample Turbidity Test Results: Submit daily.

1.03 DEWATERING PLAN

A. As a minimum, include:

1. Descriptions of proposed groundwater control facilities including, but not limited to, equipment; methods; standby equipment and power supply, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
2. Drawings showing locations, dimensions, and relationships of elements of each system.
3. Temporary piezometers at the locations shown on the Contract Drawings.
4. A schedule of the anticipated time required dewater the Site prior to starting excavation.
5. Design calculations demonstrating adequacy of proposed dewatering systems and components, and basis for the dewatering schedule.

B. If system is modified during installation or operation, revise or amend and resubmit Dewatering Plan for review and approval.

PART 2 PRODUCTS (NOT USED)**PART 3 EXECUTION**

3.01 GENERAL

- A. Continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water.

3.02 SURFACE WATER CONTROL

- A. See Section 01 51 00, Field Office and Temporary Facilities, Article Temporary Controls.
- B. Remove surface runoff controls when no longer needed.

3.03 DEWATERING SYSTEMS

- A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain the phreatic surface a minimum of 2 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.
- B. Dewatering systems shall include equipment and appurtenances sufficiently below lowest point of excavation to maintain specified groundwater elevation.
- C. Design and Operate Dewatering Systems:
 - 1. To prevent loss of ground as water is removed.
 - 2. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
- D. Provide sufficient redundancy in each system to keep excavation free of water and to prevent bottom heave in event of component failure.
- E. Provide 100 percent emergency power backup with automatic startup and switchover in event of electrical power failure.

3.04 ARTESIAN GROUNDWATER

- A. Artesian conditions within the Project limits were not encountered in the subsurface investigations reported by Strata, Inc. (2014). If artesian conditions are encountered during execution of the Work, the artesian conditions shall be verified by the Dewatering Engineer.

- B. If artesian conditions are verified by the Dewatering Engineer and the Contractor demonstrates that the artesian conditions are causing harm, the Owner will negotiate additional compensation to the Contractor for additional dewatering work directed by the Dewatering Engineer to control the artesian conditions.
- C. Additional dewatering work directed by the Dewatering Engineer shall be submitted in a revised Dewatering Plan.

3.05 MONITORING WELLS

- A. **Monitoring Groundwater Levels:** Install and monitor observation wells (also called piezometers or monitoring wells) at locations identified in the Contractor's Dewatering Plan. Measure water levels observed in each observation well at frequency stated in Contractor's Dewatering Plan and whenever system or component failures are discovered and whenever any event, including but not limited to flood, storms, changes in water surface elevation of nearby water bodies, may have caused a change in the groundwater elevation.
- B. A minimum of three temporary piezometers shall be installed in the footprint of the PEPS, and a minimum of three temporary piezometers shall be installed in the footprint of Aeration Basin No. 3. The three piezometers in each footprint shall be installed to depths of 25, 35, and 45 feet (or top of rock, whichever is shallower). The piezometers may be installed as separate observation wells within the footprint or as nested piezometers, whichever the Dewatering Engineer deems necessary to properly observe water levels. Additional observation wells may be required by the Dewatering Engineer.
- C. Excavation for the PEPS and Aeration Basin No. 3 shall not begin and temporary piezometers shall not be abandoned or demolished until water level readings demonstrate that the groundwater level is at least 2 feet below the bottom of excavation for at least 24 hours and approval to proceed with excavation is obtained from the Owner. If the groundwater level rises higher than 2 feet below the bottom of excavation, excavation shall be stopped and further dewatering measures shall be implemented by the Contractor as directed by the Dewatering Engineer.
- D. After groundwater level observation wells are no longer needed for monitoring groundwater levels, abandon Contractor-installed observation wells.

3.06 SETTLEMENT

- A. **Monitoring Dewatering-Induced Settlement:** Establish monuments for monitoring settlement at nearby existing facilities, including Primary Clarifier

No. 1 and the parshall flume and associated piping. Monitor vertical movement of each settlement monument, relative to remote benchmark selected by Engineer, at frequency stated in Contractor's Dewatering Plan.

3.07 MONITORING FLOWS

- A. Monitor volume of water pumped per calendar day from excavations, as Work progresses. Also monitor volume of water introduced each day into excavations for performance of Work. Monitor flows using measuring devices acceptable to Engineer.

3.08 DISPOSAL OF WATER

- A. Extracted groundwater shall be pretreated by the Contractor before disposing. The groundwater shall be pretreated to reduce turbidity to no more than 300 Nephelometric Turbidity Units (NTU). Take a grab sample daily of pretreated groundwater and test the turbidity.
- B. Dispose of pretreated groundwater meeting the turbidity limit into the plant headworks.
- C. Discharge water as required by discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.

3.09 PROTECTION OF PROPERTY

- A. Make assessment of potential for dewatering induced settlement. Provide and operate devices or systems, including but not limited to reinjection wells, infiltration trenches and cutoff walls, necessary to prevent damage to existing facilities, completed Work, and adjacent property.
- B. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but not be limited to, bracing, underpinning, or compaction grouting.

3.10 REMEDIATION OF GROUNDWATER DEPLETION

- A. If dewatering reduces quantity or quality of water produced by existing wells, furnish temporarily supply water to affected well owners from other sources. Furnish water of a quality and quantity equal to or exceeding the quality and quantity available to well owner prior to beginning the Work or as satisfactory to each well owner.

END OF SECTION

**SECTION 31 41 00
SHORING****PART 1 GENERAL**

1.01 SUBMITTALS

A. Informational Submittals:

1. Excavation support plan.
2. Movement monitoring plan.
3. Movement measurement and data and reduced results indicating movement trends.

1.02 QUALITY ASSURANCE

- A. Provide surveys to monitor movements of facilities adjacent to and potentially impacted by shoring, including Primary Clarifier No. 1.

PART 2 PRODUCTS (NOT USED)**PART 3 EXECUTION**

3.01 GENERAL

- A. Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work. Existing facilities near the Project include Primary Clarifier No. 1, a parshall flume, and associated piping.

3.02 EXCAVATION SUPPORT PLAN

- A. Prepare an excavation support plan addressing the following topics:
 1. Details of shoring, bracing, sloping, or other provisions.
 2. Design assumptions and calculations. Shoring design shall be by a Professional Engineer registered in the State of Idaho.
 3. Methods and sequencing of installing excavation support.
 4. Proposed locations of stockpiled excavated material.
 5. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.
 6. Anticipated difficulties and proposed resolutions.

3.03 MOVEMENT MONITORING PLAN

A. Prepare movement monitoring plan addressing following topics:

1. Survey control.
2. Location of monitoring points.
3. Plots of data trends.
4. Interval between surveys.

3.04 REMOVAL OF EXCAVATION SUPPORT

- A. Remove excavation support in a manner that will maintain support as excavation is backfilled.
- B. Do not begin to remove excavation support until support can be removed without damage to existing facilities, completed Work, or adjacent property.
- C. Remove excavation support in a manner that does not leave voids in the backfill.

END OF SECTION

SECTION 33 05 16.13
PRECAST CONCRETE UTILITY STRUCTURE

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): HB-17, Standard Specifications for Highway Bridges, Division 1 Section 3, Division I Design-Loads (Part A, Part B, Part C).
 2. ASTM International (ASTM):
 - a. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
 - b. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - c. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
 - d. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
 - e. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - f. C858, Standard Specification for Underground Precast Concrete Utility Structures.
 - g. D4101, Standard Specification for Propylene Injection and Extrusion Materials.
 3. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR 1910.27, Fixed Ladders.
 - b. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.

1.02 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings:
 - a. Detailed drawings showing complete information for fabrication including, but not limited to:
 - 1) Member dimensions and cross sections; location, size, and type of reinforcement, including additional reinforcement.
 - 2) Layout dimensions and identification of each precast unit.
 - 3) Welded connections indicated by AWS standard symbols.
 - 4) Details of connections, joints, accessories, and openings or inserts.

- 5) Watertight joint details where required.
- 6) Location and details of anchorage devices.
- 7) Access door details.
- 8) Details of polypropylene steps (where shown on Drawings).
- b. Product Data:
 - 1) Precast concrete items; show materials of construction by ASTM reference and grade.
 - 2) Joint sealants.

B. Informational Submittals:

- 1. Manufacturer’s data for lifting devices for handling and erection.
- 2. Manufacturer’s certification that vault design and manufacture comply with referenced ASTMs (for example, ASTM C857 and ASTM C858).
- 3. Vault design calculation shall be signed by a civil or structural engineer registered in the State of Idaho.
- 4. Manufacturer’s laboratory test reports.
- 5. Certified load test data for polypropylene steps.

1.03 DELIVERY, STORAGE, AND HANDLING

- A. Store each unit in a manner that will prevent cracking, distortion, warping, straining and other physical damage, and in a manner to keep marking visible.
- B. Lift and support each unit only at designated lifting points and supporting points as shown on Shop Drawings.

PART 2 PRODUCTS

2.01 VAULT MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of:
 - 1. Oldcastle Precast.
 - 2. Jensen Precast.
 - 3. Hanson Pipe and Precast.

2.02 PRECAST CONCRETE VAULTS

- A. Design Requirements:
 - 1. In the event of a conflict between or among standards, the more stringent standard shall govern.
 - 2. Comply with ASTM C858, except as modified herein.

3. Reinforcing Steel:
 - a. Deformed Bars: ASTM A615/A615M, Grade 60.
 - b. Welded Wire Fabric: ASTM A497/A497M.
 4. Nominal Dimensions: As shown on Drawings.
 5. Construction: Rigid type and behave monolithically. Do not use panel-type vaults.
 6. Design Loads: As determined by ASTM C857, and by using Site-specific values below.
 - a. Unit Weight of Soil: 125 pounds per cubic foot.
 - b. Active Earth Pressure Coefficient: 40 psf/ft (drained), 75 psf/ft (undrained).
 - c. Groundwater Level:
 - 1) Normal High Groundwater Elevation: Plus or minus 2450.00 feet.
 - 2) 100 Year Flood Groundwater Elevations: Plus or minus 2459.00 feet.
 - d. Live Loads: AASHTO HS20-44 truck loading plus impact.
 - e. Designed to avoid flotation with a factor of safety equal to 1.2.
 7. Design shall accommodate additional stresses or loads that may be imposed during factory precasting, transporting, erection, and placement.
 8. Blockouts for penetrations shall be as shown on Drawings.
 9. Sealant:
 - a. Nonswelling preformed joint sealants to provide a lasting, watertight bond.
 - b. Manufacturer and Product: Henry Company; RAM-NEK.
 10. Mortar: Comply with ASTM C387/C387M, Type S or use Type I grout as specified in Section 03 62 00, Nonshrink Grouting.
- B. Mark each member or element to indicate location in the structure, top surface, and date of fabrication.
- C. Vault Floor: Slope of vault floor shall be as shown on Drawings.

2.03 ACCESSORIES

- A. Polypropylene Steps (where indicated on drawings):
1. Fabricate from minimum 1/2-inch, Grade 60, steel bar meeting ASTM A615/A615M.
 2. Polypropylene Encasement: Conform to ASTM D4101.
 3. Minimum Width: 13 inches, center-to-center of legs.
 4. Embedment: 3-1/2 inches minimum and 4-1/2-inch minimum projection from face of concrete at point of embedment to center of step.

5. Cast in vault sections by manufacturer.
6. Load Test: Capable of withstanding ASTM C478 vertical and horizontal load tests.

B. Pipe Connections to Vault: Detail as identified on Drawings.

PART 3 EXECUTION

3.01 GENERAL

- A. Possible Settlement: If subgrade is encountered that may require removal to prevent structure settlement, notify Engineer. Engineer will determine depth of over excavation and means of stabilizing subgrade prior to structure installation.
- B. Place 6-inch minimum thickness of imported crushed aggregate material on undisturbed earth or modified subgrade; thoroughly compact with a mechanical vibrating or power tamper. Meet requirements of Article Excavation and Backfill.

3.02 EXCAVATION AND BACKFILL

- A. Remove and keep water clear from excavation during construction.
- B. Excavation: As specified in Section 31 23 16, Excavation.
- C. Backfill: As specified in Section 31 23 23, Fill and Backfill, and Section 31 23 23.15, Trench Backfill.

3.03 INSTALLATION

- A. Concrete Base:
 1. Place on prepared subgrade.
 2. Properly locate, ensure firm bearing throughout, and plumb first section.
- B. Sections:
 1. Carefully inspect precast sections to be joined.
 2. Thoroughly clean ends of sections to be joined.
 3. Do not use sections with chips or cracks.

- C. Joints:
 - 1. Fill joints between precast sections per manufacturer's recommendation.
 - 2. Joints shall be watertight to prevent entrance of groundwater.
 - 3. Lid joints shall also be watertight to prevent the entrance of rainwater.
- D. Setting Precast Vault: Install vault to elevations shown on Drawings or as required by pipe elevations.
- E. Watertight construction below grade with no open cracks or spalls. Cracking and defective areas of concrete shall be repaired per requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 64 23, Crack Repair Epoxy Injection Grouting.

3.04 PIPE CONNECTION TO VAULT

- A. Install products in accordance with manufacturer's instructions.

END OF SECTION

SECTION 33 46 16
UNDERDRAIN SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. This section covers the Work necessary for the underdrain system.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. M 252, Standard Specification for Corrugated Polyethylene Drainage Tubing.
 - b. M 294, Interim Specification for Corrugated Polyethylene Pipe, 12- to 24-Inch Diameter.
 2. ASTM International (ASTM):
 - a. D3350, Polyethylene Plastics Pipe and Fittings Materials.
 - b. F1336, Standard Specification for Poly(Vinyl Chloride) (PVC) Gasketed Sewer Fittings.

PART 2 PRODUCTS

2.01 UNDERDRAIN PIPE

- A. Underdrain pipe shall consist of high-density polyethylene corrugated pipe with an integrally formed smooth interior. Perforated pipe shall be used in the locations shown on the Drawings. Perforated polyethylene tubing shall conform to AASHTO M 252, Type SP. All pipe shall be slotted unless otherwise shown.
- B. All fittings and couplings shall be as specifically manufactured for the pipe. Perforated pipe shall be joined by split couplings with gaskets conforming to AASHTO M 252. Solid pipe shall be joined by double bell watertight joints which meet the requirements of ASTM F1336, except that the inside dimensions of the bells shall match the outside dimensions of the pipe.
- C. Pipe perforations shall be the slotted type and shall conform to AASHTO M 252.

- D. Pipe and fittings shall be manufactured from high-density polyethylene resin which shall meet or exceed the requirements of Cell Class 324420 C (minimum) as defined and described in ASTM D3350, except that the carbon black content shall not exceed 5 percent.
- E. Pipe shall be as manufactured by Advanced Drainage Systems, Inc. of Hilliard, OH, or Hancor, Inc., of Findlay, OH, or approved equivalent.

2.02 DRAIN ROCK

- A. As specified in ISPWC Section 801 except with the following gradation:

U.S. Standard Sieve Size	Percent Passing by weight
1 inch	100
1/2 inch	40-100
3/8 inch	0-10
No. 4	0-5
No. 200	0-2

PART 3 EXECUTION

3.01 PREPARATION OF TRENCH

- A. Trench Excavation: Excavation shall be as specified under applicable parts of ISPWC Section 301, Trench Excavation, and Section 306, Trench Backfill. Place and compact Drain Rock to the lines shown and as described in Section 306, Trench Backfill, and trench into drain gravel to install underdrain pipe.
- B. Removal of Water: At all times, provide and maintain ample means and devices to remove and dispose of water entering the trench during the laying operation to the extent required to properly grade the bottom of the trench and allow for proper compaction of the backfill in the pipe zone. Do not lay pipe in water.
- C. Preparation of Pipe Prior to Installation: Inspect all pipe and fittings before lowering into the prepared trench to ensure that no cracked, broken, or defective pipe or fittings are being used in the Work. Clean the ends of the pipe thoroughly. Remove foreign matter and dirt from the inside of the pipe. Ensure that the inside surfaces are smooth and free from any projections which would interfere with the assembly or watertightness of the joint.

- D. Handling: Provide and use proper implements, tools, and facilities for the safe and proper protection of the Work. Lower all pipe into the trench in such a manner as to avoid any physical damage to the pipe. Reject all damaged pipe and remove from the Job Site. Do not drop or dump pipe into the trench under any circumstances.
- E. Line and Grade: Maximum deviation from true line or grade, as established by the Engineer, shall not exceed 1/2-inch for line and 1/4-inch for grade provided that such variation does not result in a level or reverse sloping invert.

3.02 INSTALLATION OF UNDERDRAIN PIPE

- A. The locations of the slotted underdrain are shown. Bring the subgrade to the final elevation, dig trenches, and place subgrade separation geotextile as specified in ISPWC Section 2050, Geotextiles. Bring Drain Rock to the level of the bottom of pipe, and lay the slotted pipe on a true alignment in the prepared trench as shown. Face joints in direction opposite of flow if interlocking joints are used. Orient so that two slots face down.
- B. After a section of pipe has been lowered into the prepared trench, wipe the end of the pipe to be joined and the inside of the joint clean immediately before joining the pipe. Make the joint in strict accordance with the recommendations of the manufacturer. Provide all special tools and appliances required for the jointing assembly.
- C. Joints shall be made in complete conformance with pipe manufacturer recommendations whether done by butt fusion or mechanical interlock. After the joint has been made, align and check the pipe for grade. The trench bottom shall form a continuous and uniform bearing and support for the pipe at every point between joints. Apply sufficient pressure in making the joint to assure that joint is "home" as defined in the standard installation instructions provided by the pipe manufacturer. To assure proper pipe alignment and joint makeup, place sufficient pipe zone material to secure the pipe from movement before the next joint is installed.
- D. Prevent soil or other foreign material and debris from getting into the pipe during the laying operation. At all times when laying operations are not in progress, at the close of the day's work or during periods of inactivity, close and block the open end of the last laid section of pipe to prevent entry of foreign material or creep of the gasketed joints.

3.03 BACKFILLING

- A. Placing of Drain Rock: Place around pipe as shown.
- B. Backfill: Accomplish backfill in accordance with the applicable portions of ISPWC Section 306, Trench Backfill, and Section 204, Structural Excavation and Compacting Backfill.

END OF SECTION

**SECTION 35 20 16.24
SLIDE GATES**

PART 1 GENERAL

EQUIPMENT AND COMPONENT NUMBER(S)

Equipment Number	Equipment Name
3126GTECB3	Collection Box 3 PEPS Isolation Gate
4480GTEAB3	Aeration Basin 3 Effluent Gate

1.01 GENERAL REQUIREMENTS

- A. See Division 01, General Requirements, which contains information and requirements that apply to the Work specified herein and are mandatory for this Project.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME): B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
 2. American Water Works Association (AWWA): C561, Fabricated Stainless Steel Slide Gates.
 3. ASTM International (ASTM):
 - a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - d. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - e. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
 - f. D1056, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
 - g. D2000, Standard Classification System for Rubber Products in Automotive Applications.

- h. D4020, Standard Specification for Ultra-High-Molecular-Weight Polyethylene Molding and Extrusion Materials.
- i. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
- j. F594, Standard Specification for Stainless Steel Nuts.
- 4. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).

1.03 DEFINITIONS

- A. EPDM: Ethylene propylene diene monomer.
- B. Self-Contained: The arrangement of gate operator, supported by gate frame, such that operating thrust loads are not applied external to gate assembly.
- C. Slenderness Ratio: The ratio of maximum unsupported stem length to stem cross-section radius of gyration.
- D. UHMWPE: Ultra high molecular weight polyethylene.

1.04 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Drawings:
 - a. Equipment Assembly: Make, model, weight, and horsepower of each.
 - b. Manufacturer's catalog information, descriptive literature, specifications, dimensional layouts, and identification of materials of construction.
 - c. Detailed mechanical and electrical drawings showing equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work, and weights of associated equipment.
 - d. Gate opening and closing thrust forces that will be transmitted to support structure with operator at extreme positions and load.
 - e. Gate operator and stem calculations for each gate and service condition.
 - f. Functional description of internal and external instrumentation and controls to be supplied including list of parameters monitored, controlled, or alarmed.
 - g. Power and control wiring diagrams, including terminals and numbers.
 - h. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Anchorage and Bracing Requirements.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 60 01, Anchorage and Bracing Requirements.
2. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Leakage measurements from factory test results.
4. Special shipping, storage and protection, and handling instructions.
5. Manufacturer’s installation instructions.
6. Routine maintenance requirements prior to plant startup.
7. Operation and Maintenance Data: As specified in Section 01 70 00, Operation and Maintenance Information.
8. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.

1.05 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage following spare parts and special tools.

<u>Item</u>	<u>Quantity</u>
Stem collars for gate stems	One of each different size
Bronze lift nuts	One of each different size
Indicator lights	One-half dozen
Special tools required to maintain or dismantle	One complete set

- B. Delivery: In accordance with Section 01 61 00, Common Product Requirements and Section 01 66 00, Shipment, Protection and Storage.

PART 2 PRODUCTS

2.01 SUPPLEMENTS

- A. See supplements to this section for additional product information.

2.02 FULL-APERTURE SEALING SLIDE GATES

- A. General: Unless otherwise specified, conform to AWWA C561.
- B. Performance Requirements: Installed gate leakage at the specified design heads shall not exceed 0.05 gpm per foot of seating, or 0.10 gpm per foot of unseating, perimeter length.

C. Materials:

1. Thimble, Frame, Guides, Slide, Yoke, and Stem Guides:
ASTM A240/A240M and ASTM A276, Type 304L stainless steel.
2. Stem and Couplings: ASTM A276, Type 304 stainless steel.
3. Seals: ASTM D1056, EPDM; ASTM D2000, resilient neoprene; or
ASTM D4020, UHMWPE.
4. Guide Liner: ASTM D4020, UHMWPE.
5. Fasteners: ASTM F593, ASTM F594, GR2, Type 316 stainless steel.
6. Lift Nut: ASTM B584, bronze.
7. Thrust Nut:
 - a. Rising Stem: ASTM A240/A240M or ASTM A194/A194M,
Type 316 stainless steel.

D. Frame:

1. Stainless steel, minimum material thickness of 1/4 inch.
2. Construction:
 - a. Made of structural members or formed plate welded to form a rigid one-piece frame.
 - b. Flange back design that allows for mounting directly on a wall thimble or pipe flange as required.
 - c. Seating face of frame shall be machined or orientated at an angle to the plane of the mounting flange to effect a wedging action upon closure.
 - d. Wedges necessary for meeting seating and unseating head conditions and leakage requirements shall be stainless steel with UHMWPE seats.
3. Vertical Guides for Self-contained Gates:
 - a. Design for maximum rigidity and extend in one continuous piece from gate invert to form posts for support of gate operators.
 - b. When guides extend above operating floor, they shall be sufficiently strong so that no further reinforcements are required.
 - 1) Weight: Not less than 9 pounds per linear foot for stainless steel.
 - 2) Incorporate a replaceable UHMWPE bearing strip in a retainer slot on downstream/unseating head side of gate.
4. Frame Invert: For flush bottom gates, furnish a resilient neoprene seal to function as a seating surface for the gate slide.
 - a. Weight: Not less than 9 pounds per linear foot for stainless steel.
5. Join vertical guide frames and invert with factory welded corners.
6. Size guided slot to provide a minimum slide engagement of 1 inch on each side.

E. Slide:

1. Consisting of a single flat plate, stainless steel with minimum thickness of 1/4 inch, reinforced with formed plates or structural members welded to slide to limit deflection.
 - a. Deflection shall not exceed 1/360th of gate width at maximum design head.
2. Machine to match frame.

F. Guide Liners:

1. UHMWPE, attached to slide or frame by means of studs, and of such length as to retain and support at least two thirds of the vertical height of the slide in the fully open position.
2. Adjustable by means of adjusting bolts.

G. Operator Support Yoke:

1. For self-contained gate operators, attached to vertical extensions of guide frames, designed to allow for removal of slide from gate assembly.
2. Constructed from at least two stainless steel angles, or two other suitable shapes, and bolt in place to provide a rigid assembly.
3. Maximum Deflection: Not to exceed 1/4 inch under full operator applied loading.

H. Stems and Couplings:

1. Diameter as required, 1-inch minimum.
2. Threads: Acme type with RMS surface roughness of 63 micro-inches or less on flanks for manually operated gates and 32 micro-inches or less on flanks for electrically operated gates. Extend threaded portion of stem 2 inches above operator when gate is in CLOSED position.
3. Connection: Designed to prevent rotation of thrust nut or thru-bolt that connects stem to slide.
 - a. Rising Stems: Thrust nut threaded and keyed or pinned to stem.
4. Couplings:
 - a. Use when stems have more than one section.
 - b. Same material as stem.
 - c. Furnish with internal threads that transmit full thrust of stem.
 - d. Hold in place on stem with bolts or keys and keyways.
 - e. Same size and interchangeable.
5. Size so slenderness ratio of unsupported stem length (L) to radius of gyration (r), both in inches, does not exceed 200.

6. Withstand in compression, without damage, thrust equal to at least 2-1/2 times rated output of hoisting mechanism, with a 40-pound effort applied to handwheel or crank.
7. Cast iron or bronze bushed stem guides, mounted on fabricated wall brackets, adjustable in two directions and spaced so that L/r ratio does not exceed 200.
8. Adjustable stop collar for CLOSED position.
9. Connect stems to disc plate with a yoke, bolted to stem and welded to disc.
10. Gates having a width greater than twice the height shall have dual stems. For downward opening weir type gates, locate stems near outside edges of gate.

I. Stem Covers:

1. Transparent plastic, vented pipe stem cover and cap.
2. OPEN/CLOSED designators and with 1-inch graduations on clear mylar, pressure sensitive, adhesive tape, suitable for outdoor application.

J. Seals:

1. Specially molded shape secured to frame or slide, designed to remain in place during life of gate.
2. Shaped to produce a wide sealing area to form a flush invert.
3. Make top surface of seal flush with invert of gate opening.
4. Machine full length of bottom edge of slide accurately to make contact with seal when slide is closed.

K. Manufacturers:

1. H. Fontaine, Ltd.
2. Rodney Hunt Co.
3. HydroGate Corp.
4. Whipps, Inc.

2.03 OPERATORS

A. General:

1. Components: Withstand a minimum of 250 percent of design torque or thrust at extreme operator positions without damage.
2. Mount at walkway level, 36 inches above floor, unless otherwise indicated.
3. Gear train and gate stem sections shall produce a self-locking drive train.

4. Lift Nuts: Internally threaded with cut or cold-rolled Acme threads corresponding to stem threading.
5. Roller Bearings: Ball-thrust or tapered above and below lift nut to support both opening and closing thrusts.
 - a. Grease lubrication fittings for bearings.
 - b. Input pinions with needle or ball bearings.
6. Lubrication: Furnish rising stem gates with an insert lubricator flange in lift with a grease fitting for greasing stem threads below stem nut.

B. Dual-Stem Gate Operators:

1. Enclosed, geared bench stands.
2. Interconnect so operators will work as a unit from single point with electric operator.
3. Interconnecting Shafts:
 - a. Stainless steel with flexible couplings at ends.
 - b. Diameter sufficient to prevent sagging.
4. Include flanged coupling to allow precision slide leveling.
5. Provide extension stem to allow actuator to be mounted remotely from gate as shown the Drawings.

C. Type 4, Electric Motor Operators:

1. 28-inch high steel pedestal or direct yoke-mounted, totally enclosed weatherproof electric drive unit, and a totally enclosed gear box that operates a two-piece, bronze stem nut, which lifts gate stem.
2. Gears: Heat treated alloy steel, supported throughout by antifriction ball or roller bearings and grease lubricated.
3. Automatic double-acting geared limit switches and double-acting torque switches.
 - a. Gear directly to operating gear train and shall be “in step” at all times, whether in motor or manual operation.
 - b. Wire geared limit switches internally to stop motor at fully OPEN and fully CLOSED positions.
 - c. Wire torque switches internally so that, in the event of a mechanical overload in either direction, motor will be stopped.
4. Equip with side-mounted handwheel for manual operation.
 - a. Include automatic clutch to positively disengage handwheel at any time drive motor control is energized.
 - b. Design handwheel operator so failure of motorized gearing will not prevent hand operation of gate.
5. Drive Unit:
 - a. TENV, 480-volt, three-phase electric motor as specified in Section 26 20 00, Low-Voltage AC Induction Motors, with integral OPEN/STOP/CLOSE weatherproof pushbuttons,

- reversing controller, 480/120-volt control power transformer, space heaters in the limit switches and in the control compartments, mechanical dial type position indicator, and transparent plastic pipe stem cover and cap unless otherwise specifically noted on the Drawings.
- b. Furnish motor enclosure with drainage and breathing holes.
- c. Self-locking, with approximately 12 inches per minute gate travel speed, and a rated running torque equal to 20 percent of motor starting torque at a rated running time of 15 minutes, without exceeding allowable NEMA temperature rise for insulation class used.
- 6. Operation: Drive the gate to its fully OPEN or CLOSED position when OPEN or CLOSED pushbutton is depressed momentarily. Motor shall stop in mid-travel when STOP button is depressed.
- 7. Controls: Furnish the following in accordance with operator control styles listed below and specified in the Slide Gate Schedule:

Feature	Description
A	Local OPEN/STOP/CLOSE pushbutton station.
B	End position limit switches; OPEN and CLOSED position switches shall be normally open contacts that close at the end position; contacts shall be dry and rated for 5 amps, 120V ac.
C	Continuous position output; provide a transmitter to generate a 4 mA to 20 mA dc signal to an external loop in direct proportion to gate position; transmitter shall be factory mounted in a NEMA 250, Type 4 enclosure. Transmitter shall be capable of driving an external load impedance of 350 ohms minimum.
D	LOCAL/REMOTE weatherproof selector switch and provisions for remote OPEN/STOP/CLOSE operation; remote commands will be by way of a four-wire circuit, as shown; motor operator shall impress voltage required to read these contacts and shall go to commanded position or stop when in REMOTE mode. Provide auxiliary contact which closes when LOCAL/REMOTE switch is in REMOTE position.

- a. Operator Control Styles:
 - 1) Style 3: Includes control features A, B, and D.
 - 2) Style 4: Includes control features A, B, C, and D.

8. Manufacturers and Products:
 - a. Limitorque; MX Series.
 - b. Rotork, IQ series.
 - c. Or equal.

D. Identification Tagging Requirements:

1. For each gate operator, 1-1/2-inch minimum diameter, stainless steel or heavy brass tag, bearing gate tag number shown in schedule.
2. Attach tags to operator by soldered split key rings so ring and tag cannot be removed. Use block type numbers and letters with 1/4-inch minimum high numbers and letters stamped on and filled with black enamel.

2.04 APPURTENANCES

- A. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.
- B. Anchor Bolts: ASTM A193/A193M, Type 316 stainless steel sized by equipment manufacturer, at least 1/2 inch in diameter or as shown and as specified in Section 05 50 00, Metal Fabrications.
- C. Fasteners: Assembly bolts, studs, nuts, and fasteners for wall thimble and pipe flange mounting, shall be provided to mate with the gate frame drilling. Bolting on circular flanged-back gates mounting to pipe flanges shall conform to ASME B16.1 Class 125 drilling, and rated for shear loads required for gate operation.
- D. Wedges: Adjustable wedges or pressure pads shall be provided as necessary to ensure gates meet specified leakage requirements. Such adjusting mechanisms shall prevent rotation and lateral motion of gates, and remain securely in place after adjustment.

2.05 SHOP/FACTORY FINISHING

- A. None required for stainless steel.
- B. Factory prepare, prime, and finish coat other exposed metal surfaces in accordance with Section 09 90 00, Painting and Coating.

2.06 SOURCE QUALITY CONTROL

- A. Factory Tests and Adjustments: Fully assemble and test gates actually furnished.
 1. Functional Test: Perform manufacturer's standard test on equipment.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In accordance with manufacturer's written instructions.
- B. Accurately place anchor bolts using templates furnished by manufacturer and as specified in Section 05 50 00, Metal Fabrications.
- C. Grease threads above stem nut prior to placing gate in operation.

3.02 FIELD QUALITY CONTROL

- A. Functional Tests: Conduct on each gate.
- B. Performance Test:
 - 1. Conduct on each gate in accordance with AWWA C561.
 - 2. Perform under actual or approved simulated operating conditions.
 - 3. Test for a continuous 30-minute period without malfunction.
 - 4. Adjust, realign, or modify units and retest if necessary.

3.03 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
 - 1. 1/2 person-day for installation assistance and inspection.
 - 2. 1/2 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
 - 3. 1/2 person-day for prestartup classroom or Site training.
 - 4. See Section 01 43 33, Manufacturers' Field Services, and Section 01 75 00, Testing, Equipment Startup, and Commissioning.
- B. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

3.04 SUPPLEMENTS

- A. The supplement listed below, following “End of Section”, is a part of this Specification.
 - 1. Slide Gates Schedule.

END OF SECTION

Slide Gates Schedule							
Gate Identification No. and Location	Assembly Style	Wall Opening (width/height inches)	Gate Width/ Height (inches)	Gate Invert and Top Of Yoke or Stand Mounting Surface Elevations	Material	Design Operating Head (feet) Seating/ Unseating Condition	Operator Type/ Control Style
3126GTECB3 Collection Box 3	Self-contained, downward closing, wall surface mount, non-flush invert, full aperture sealing	48 diameter DI pipe (50.8 inch OD)	48/48	2446.86/2461	Type 304 stainless steel	10 seating	Type 4/Style 3
4480GTEAB3 Aeration Basin 3 Effluent Box	Self-contained, downward opening weir gate, wall surface mount, dual stem	114 wide	114/	Concrete Weir and Top of Slide Fully Down El 2457.31/ Top of Slide Fully Up 2462.0/Top of Yoke 2466.8	Type 304 stainless steel	7 seating	Type 4/Style 4

SECTION 40 05 15
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
 2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
 3. ASTM International (ASTM):
 - a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
 - c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 4. International Code Council (ICC):
 5. International Building Code (IBC).
 6. International Mechanical Code (IMC).
 7. Manufacturers' Standardization Society (MSS):
 - a. SP 58, Pipe Hangers and Supports—Materials, Design and Manufacture.
 - b. SP 127, Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.

1.02 DEFINITIONS

- A. Wetted or Submerged: Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel, tank, or in other damp locations.

1.03 SUBMITTALS

- A. Action Submittals:
1. Catalog information and drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for piping 6 inches and larger. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.
 2. Calculations for each type of pipe support, attachment and anchor.

3. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
4. Anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Anchorage and Bracing Requirements.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 60 01, Anchorage and Bracing Requirements.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
3. Maintenance information on piping support system.

1.04 QUALIFICATIONS

- A. Piping support systems shall be designed and Shop Drawings prepared and sealed by a Registered Professional Engineer in the state where the Work is to be installed.

1.05 DESIGN REQUIREMENTS

A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Piping Smaller than 30 Inches: Supports are shown only where specific types and locations are required; additional pipe supports may be required.
3. Piping 30 Inches and Larger: Support systems have been designed for piping shown.
4. Meet requirements of MSS SP 58 and ASME B31.1 or as modified by this section.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes or internal pressures, including insulation and weight of fluid in pipes.
2. Seismic loads in accordance with governing codes and as shown on Structural General Drawings.
3. Wind loads in accordance with governing codes and as shown on Structural General Drawings.
4. Maximum Support Spacing and Minimum Rod Size: In accordance MSS SP 58 Table 3 and Table 4.
 - a. Ductile-iron Pipe 8 Inches and Under: Maximum span limited to that for standard weight steel pipe for water service.

- b. Ductile-iron Pipe 10 Inches and Larger: Maximum span limited to 20 feet.
- C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.
- D. Vertical Sway Bracing: 10-foot maximum centers or as shown.
- E. Existing Support Systems: Use existing supports systems to support new piping only if Contractor can show they are adequate for additional load, or if they are strengthened to support additional load.

PART 2 PRODUCTS

2.01 GENERAL

- A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.
- B. Special support and hanger details may be required for cases where standard catalog supports are not applicable.
- C. Materials: In accordance with the Area Classification and Material Selection Table on the Drawings.

2.02 HANGERS

- A. Clevis: MSS SP 58, Type 1:
 - 1. Anvil; Figure 260 for steel pipe and Figure 590 for ductile-iron pipe, sizes 1/2 inch through 30 inches.
 - 2. Insulated Steel Pipe: Anvil; Figure 260 with insulated saddle system (ISS), sizes 1/2 inch through 16 inches.
 - 3. B-Line; Figure B3100, sizes 1/2 inch through 30 inches.
- B. Adjustable Swivel Split-Ring Pipe Clamp: MSS SP 58, Type 6:
 - 1. Anvil; Figure 104, sizes 3/4 inch through 8 inches.
 - 2. B-Line; Figure B3171, sizes 3/4 inch through 8 inches.
- C. Steel Yoke Pipe Rolls and Roller Supports: MSS SP 58, Type 41 or Type 43:
 - 1. Anvil; Figure 181 for sizes 2-1/2 inches through 24 inches, and Figure 171 for sizes 1 inch through 30 inches.
 - 2. B-Line; Figure B3110 for sizes 2 inches through 24 inches and Figure B3114 for 30 inches.

- D. Pipe Rollers and Supports: MSS SP 58, Type 44:
 - 1. Anvil; Figure 175, sizes 2 inches through 30 inches.
 - 2. B-Line; Figure B3120, sizes 2 inches through 24 inches.

2.03 WALL BRACKETS, SUPPORTS, AND GUIDES

- A. Welded Steel Wall Bracket: MSS SP 58, Type 33 (heavy-duty):
 - 1. Anvil; Figure 199, 3,000-pound rating.
 - 2. B-Line; Figure B3067, 3,000-pound rating.
- B. Adjustable “J” hanger MSS SP 58, Type 5:
 - 1. Anvil; Figure 67, sizes 1/2 inch through 8 inches.
 - 2. B-Line; Figure B3690, sizes 1/2 inch through 8 inches.
- C. Offset Pipe Clamp: Anvil; Figure 103, sizes 3/4 inch through 8 inches.
- D. Channel Type:
 - 1. Unistrut.
 - 2. Anvil; Power-Strut.
 - 3. B-Line; Strut System.
 - 4. Aickinstrut (FRP).

2.04 PIPE SADDLES

- A. Provide 90-degree to 120-degree pipe saddle for pipe 6 inches and larger with baseplates drilled for anchor bolts.
 - 1. In accordance with Standard Detail 4005-515.
 - 2. Sizes 20 inches through 60 inches, Piping Technology & Products, Inc.; Fig. 2000.
- B. Saddle Supports, Pedestal Type:
 - 1. Minimum standard weight pipe stanchion, saddle, and anchoring flange.
 - 2. Nonadjustable Saddle: MSS SP, Type 37 with U-bolt.
 - a. Anvil; Figure 259, sizes 4 inches through 36 inches with Figure 63C base.
 - b. B-Line; Figure B3095, sizes 1 inch through 36 inches with B3088S base.
 - 3. Adjustable Saddle: MSS SP 58, Type 38 without clamp.
 - a. Anvil; Figure 264, sizes 2-1/2 inches through 36 inches with Figure 62C base.
 - b. B-Line; Figure B3092, sizes 3/4 inch through 36 inches with Figure B3088S base.

2.05 CHANNEL TYPE SUPPORT SYSTEMS

- A. Channel Size: 12-gauge, 1-5/8-inch wide minimum steel, or 1-1/2-inch wide, minimum FRP.
- B. Members and Connections: Design for loads using one-half of manufacturer's allowable loads.
- C. Fasteners: Vinyl ester fiber, polyurethane base composite nuts and bolts, or encapsulated steel fasteners.
- D. Manufacturers and Products:
 - 1. B-Line; Strut System.
 - 2. Unistrut.
 - 3. Anvil; Power-Strut.
 - 4. Aickinstrut (FRP System).
 - 5. Enduro-Durostrut (FRP Systems).

2.06 PIPE CLAMPS

- A. Riser Clamp: MSS SP 58, Type 8.
 - 1. Anvil; Figure 261, sizes 3/4 inch through 24 inches.
 - 2. B-Line; Figure B3373, sizes 1/2 inch through 30 inches.

2.07 ELBOW AND FLANGE SUPPORTS

- A. Elbow with Adjustable Stanchion: Sizes 2 inches through 18 inches, Anvil; Figure 62C base.
- B. Elbow with Nonadjustable Stanchion: Sizes 2-1/2 inches through 42 inches, Anvil; Figure 63A or Figure 63B base.
- C. Flange Support with Adjustable Base: Sizes 2 inches through 24 inches, Standon; Model S89.

2.08 INTERMEDIATE PIPE GUIDES

- A. Type: Hold down pipe guide.
 - 1. Manufacturer and Product: B-Line; Figure B3552, 1-1/2 inches through 30 inches.

B. Type: U-bolts with double nuts to provide nominal 1/8-inch to 1/4-inch clearance around pipe; MSS SP 58, Type 24.

1. Anvil; Figure 137 and Figure 137S.
2. B-Line; Figure B3188 and Figure B3188NS.

2.09 PIPE ALIGNMENT GUIDES

A. Type: Spider.

B. Manufacturers and Products:

1. Anvil; Figure 255, sizes 1/2 inch through 24 inches.
2. B-Line; Figure B3281 through Figure B3287, sizes 1/2 inch through 24 inches.

2.10 PIPE ANCHORS

A. Type: Anchor chair with U-bolt strap.

B. Manufacturer and Product: B-Line; Figure B3147A or Figure B3147B.

2.11 SEISMIC RESTRAINTS

A. Solid pipe bracing attachment to pipe clevis with clevis cross brace and angle rod reinforcement.

B. Manufacturers:

1. Mason Industries.
2. B-Line.
3. Anvil.

2.12 ACCESSORIES

A. Anchor Bolts:

1. Size and Material: Sized by Contractor for required loads, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.
2. Bolt Length (Extension Above Top of Nut):
 - a. Minimum Length: Flush with top of nut preferred. If not flush, shall be no more than one thread recessed below top of nut.
 - b. Maximum Length: No more than a full nut depth above top of nut.

- B. Dielectric Barriers:
 - 1. Plastic coated hangers, isolation cushion, or tape.
 - 2. Manufacturer and Products:
 - a. B-Line; B1999 Vibra Cushion.
 - b. B-Line; Iso Pipe, Isolation Tape.
- C. Insulation Shields:
 - 1. Type: Galvanized steel or stainless steel, MSS SP 58, Type 40.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure 167, sizes 1/2 inch through 24 inches.
 - b. B-Line; Figure B3151, sizes 1/2 inch through 24 inches.
- D. Welding Insulation Saddles:
 - 1. Type: MSS SP 58, Type 39.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure Series 160, sizes 1 inch through 36 inches.
 - b. B-Line; Figure Series B3160, sizes 1/2 inch through 24 inches.
- E. Plastic Pipe Support Channel:
 - 1. Type: Continuous support for plastic pipe and to increase support spacing.
 - 2. Manufacturer and Product: B-Line; Figure Series B3106V, sizes 1/2 inch through 6 inches with Figure B3106 Vee bottom hanger.
- F. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.
- G. Attachments:
 - 1. I-Beam Clamp: Concentric loading type, MSS SP 58, Type 21, Type 28, Type 29, or Type 30, which engage both sides of flange.
 - 2. Concrete Insert: MSS SP 58, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
 - 3. Welded Beam Attachment: MSS SP 58, Type 22.
 - a. Anvil; Figure 66.
 - b. B-Line; Figure B3083.
 - 4. U-Channel Concrete Inserts: As specified in Section 05 50 00, Metal Fabrications.
 - 5. Concrete Attachment Plates:
 - a. Anvil; Figure 47, Figure 49, or Figure 52.
 - b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

PART 3 EXECUTION**3.01 INSTALLATION****A. General:**

1. Install support systems in accordance with MSS SP 58, unless shown otherwise.
2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.
3. Support piping connections to equipment by pipe support and not by equipment.
4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
5. Support no pipe from pipe above it.
6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
7. Do not use adhesive anchors for attachment of supports to ceiling or walls.
8. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
10. Install lateral supports for seismic loads at changes in direction.
11. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
12. Repair mounting surfaces to original condition after attachments are completed.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
 - a. Single Pipes: Clevis hangers or adjustable swivel split-ring.
 - b. Grouped Pipes: Trapeze hanger system.
2. Horizontal Piping Supported from Walls:
 - a. Single Pipes: Wall brackets, or attached to wall, or to wall mounted framing with anchors.
 - b. Stacked Piping: Wall mounted framing system and “J” hangers acceptable for pipe smaller than 3-inch.
 - c. Pipe clamp that resists axial movement of pipe through support is not acceptable. Use pipe rollers supported from wall bracket.
3. Horizontal Piping Supported from Floors:
 - a. Saddle Supports:
 - 1) Pedestal Type, elbow and flange.
 - 2) Provide minimum 1-1/2-inch grout beneath baseplate.

- b. Floor Mounted Channel Supports:
 - 1) Use for pipe smaller than 3-inch running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.
 - 2) Attach channel framing to floors with baseplate on minimum 1-1/2-inch nonshrink grout and with anchor bolts.
 - 3) Attach pipe to channel with clips or pipe clamps.
- c. Concrete Cradles: Use for pipe larger than 3 inches along floor and in trenches at pipe elevations lower than can be accommodated using stanchion type.
- 4. Insulated Pipe:
 - a. Pipe hanger and support shall be on outside of insulation. Do not enclose within insulation.
 - b. Provide precut 120-degree sections of rigid insulation (minimum length same as shield), shields and oversized hangers or insulated saddle system (ISS).
 - c. Wall-mounted pipe clips not acceptable for insulated piping.
- 5. Vertical Pipe: Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Standard Attachments:

- 1. New Concrete Ceilings: Concrete inserts, concrete attachment plates, or concrete anchors as limited below:
 - a. Single point attachment to ceiling allowed only for 3/4-inch rod and smaller (8 inches and smaller pipe).
 - b. Where there is vibration or bending considerations, do not connect a single pipe support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.
- 2. Existing Concrete Ceilings: Channel type support with minimum of two anchor points, concrete attachment plates or concrete anchors as limited below:
 - a. Single point attachment to ceiling is allowed only for 3/4-inch rod and smaller (8 inches and smaller pipe).
 - b. Where there is vibration or bending considerations do not connect a single pipe support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.
- 3. Steel Beams: I-beam clamp or welded attachments.
- 4. Wooden Beams: Lag screws and angle clips to members not less than 2-1/2 inches thick.
- 5. Concrete Walls: Concrete inserts or brackets or clip angles with concrete anchors.
- 6. Concrete Beams: Concrete inserts, or if inserts are not used attach to vertical surface similar to concrete wall. Do not drill into beam bottom.

- D. Saddles for Steel or Concrete Pipe: Provide 90-degree to 120-degree pipe saddle for pipe sizes 6 inches and larger when installed on top of steel or concrete beam or structure, pipe rack, trapeze, or where similar concentrated point supports would be encountered.
- E. Intermediate and Pipe Alignment Guides:
1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
 2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.
 3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.
- F. Accessories:
1. Insulation Shield: Install on insulated piping with oversize rollers and supports.
 2. Welding Insulation Saddle: Install on insulated steel pipe with oversize rollers and supports.
 3. Dielectric Barrier:
 - a. Provide between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and nonstainless steel ferrous metal piping.
 - b. Install rubber wrap between submerged metal pipe and oversized clamps.

3.02 FIELD FINISHING

- A. Paint atmospheric exposed surfaces hot-dip galvanized steel components as specified in Section 09 90 00, Painting and Coating.

END OF SECTION

**SECTION 40 05 33
PIPE HEAT TRACING**

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Factory Mutual.
2. Institute of Electrical and Electronics engineers, Inc (IEEE): 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
3. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. Underwriters Laboratories, Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's descriptive literature.
2. Plastic Pipe Installations: Output adjustment factors for heating tape for the services indicated.
3. Pipe heat loss calculations for each pipe size to be heat traced.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN REQUIREMENTS

A. Design Heating Load:

1. Heating load to be calculated based upon a 50 degree F delta, 20 mph wind if pipes are located outdoors, insulation as specified in Section 40 42 13, Process Piping Insulation, pipe as specified in Section 40 27 00, Process Piping—General, and shall include a 10 percent safety factor.
2. Heat loss calculations shall be based on IEEE 515, Equation 1, Page 19.

2.02 ELECTRICAL HEATING TAPE

A. Cable: Self-limiting, parallel circuit construction consisting of continuous inner core of variable resistance conductive heating material between two parallel copper bus wires. Provide tinned copper braid for PVC, FRP, and stainless steel pipe applications.

- B. UL Listing: Listed as self-limiting pipe tracing material for pipe freeze protection application in ordinary conditions.
- C. Maximum Maintenance Temperature: 150 degrees F (65 degrees C).
- D. Maximum Intermittent Temperature: 185 degrees F (85 degrees C).
- E. Service Voltage: As indicated by branch circuits provided for heat tracing on the Drawings.
- F. Manufacturers and Products:
 - 1. Raychem; BTV-CR.
 - 2. Thermon; BSX.
 - 3. Nelson; CL1-J1 or L1-J1.

2.03 CONNECTION SYSTEM

- A. Rating: NEMA 250, Type 4 and Factory Mutual approved.
- B. Operating Monitor Light: Furnish with each circuit power connection kit to indicate when heat tracing is energized.
- C. Manufacturers and Products:
 - 1. Power Connection Kit:
 - a. Raychem; JBS-100.
 - b. Thermon; PCA-1-SR or DP-L.
 - c. Nelson; PLT-BC.
 - 2. Splice Kit:
 - a. Raychem; S-150.
 - b. Thermon; PCS-1-SR.
 - c. Nelson; PLT-BS.
 - 3. Tee Kit:
 - a. Raychem; T-100.
 - b. Thermon; DS-S.
 - c. Nelson; PLT-BY.
 - 4. End Seal Kit:
 - a. Raychem; E-150.
 - b. Thermon; DE-S.
 - c. Nelson; LT-ME.
 - 5. Lighted End Seal Kit:
 - a. Raychem; E-100-L.
 - b. Thermon; DLS.
 - c. Nelson; LT-L.

2.04 SECURING TAPE

A. Plastic Piping Systems:

1. Type: Aluminum foil coated adhesive tape.
2. Manufacturers and Products:
 - a. Raychem; AT-180.
 - b. Thermon; AL-20P.
 - c. Nelson; AT-50.

B. Metallic Piping Systems:

1. Type: Glass or polyester cloth pressure sensitive tape.
2. Manufacturers and Products:
 - a. Raychem; GS54 or GT66.
 - b. Thermon; PF-1.
 - c. Nelson; GT-6 or GT-60.

2.05 PIPE MOUNTED THERMOSTAT

- A. Type: Fixed, nonadjustable, set at 40 degrees F.
- B. Sensor: Fluid-filled with 3-foot capillary.
- C. Enclosure: Glass-filled nylon, NEMA 250, Type 4X weatherproof with gasketed lid.
- D. Switch: SP-ST, UL listed, rated 22 amps, 120V ac to 240V ac.
- E. Manufacturers and Products:
 1. Raychem; DigiTrace Model AMC-F5.
 2. Thermon; E4X-1.
 3. Raychem; DigiTrace Model E507S-LS for hazardous areas.
 4. Thermon; E7-25325 for hazardous areas.

2.06 AMBIENT THERMOSTAT

- A. Type: Adjustable setting (15 degrees F to 140 degrees F).
- B. Sensor: Fluid-filled probe.
- C. Enclosure: Epoxy-coated NEMA 250, Type 4X aluminum enclosure with exposed hardware of stainless steel.
- D. Switch: SP-DT, UL or FM listed, rated 22 amps, 125V ac to 250V ac.

E. Manufacturers and Products:

1. Raychem; DigiTrace Model AMC-1A.
2. Thermon; B4X-15140.
3. Raychem; DigiTrace Model AMC-1H for hazardous areas.
4. Thermon; B7-15140 for hazardous areas.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install in accordance with the manufacturer’s instructions and recommended practices.
2. Provide insulation as specified in Section 40 42 13, Process Piping Insulation, over all pipe heat tracing.
3. Ground metallic structures or materials used for support of heating cable or on which it is installed in accordance with applicable codes.
4. Wiring between power connection points of heat tracing cable branch lines shall be provided by heat tracing system supplier.
5. Provide end of circuit pilot lights on heat tracing circuits for buried piping.

B. Electrical Heating Tape:

1. Determine required length of electrical heating tape by considering length of circuit, number and type of fittings and fixtures, design heating load, and heating tape output.
2. Where design heating load exceeds heating tape capacity, install by spiraling.
3. Derate heating tape capacity when installed on plastic piping.
4. Install on services as follows:

Service	Piping Material	Placement	Location
SI	CLDI	Abovegrade Pipe Exposed Outdoors	PEPS and Aeration Basins
RAS	CLDI	Abovegrade Pipe Exposed Outdoors	Aeration Basins
No. 4	Galv Steel and Copper Tubing	Abovegrade Pipe Exposed Outdoors	PEPS and Aeration Basins

5. Install additional heating tape at bolted flanges, valves, pipe supports, and other fittings and fixtures as recommended by supplier, but not less than the following:

Item	Heating Tape Length (min. feet)
Bolted flanges (per pair)	Two times pipe diameter
Valves	Four times valve length
Pipe hanger or support penetrating insulation	Three times pipe diameter

- C. Heat Tracing Circuits: Limit individual lengths of heat tracing circuits such that maximum single circuit capacity is 20 amps when starting the circuit at 40 degrees F. Provide multiple 20-amp circuits as required at individual heat tracing locations.
- D. Thermostats:
1. Install in accordance with manufacturer's instructions and as approved by Engineer.
 2. For each group of heat traced circuit, install one ambient thermostat.

3.02 FIELD QUALITY CONTROL

- A. Test each circuit with 500-volt insulation tester between circuit and ground with neutrals isolated from ground.
1. Insulation Resistance: Minimum 1,000 megohms per 1,000 feet.

END OF SECTION

SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:
1. Air Force: A-A-58092, Tape, Antiseize, Polytetrafluorethylene.
 2. American Association of State Highway and Transportation Officials (AASHTO): HB-17, Standard Specifications for Highway Bridges.
 3. American Petroleum Institute (API): SPEC 5L, Specification for Line Pipe.
 4. American Society of Mechanical Engineers (ASME):
 - a. Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
 - b. B1.20.1, Pipe Threads, General Purpose (Inch).
 - c. B16.1, Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250.
 - d. B16.3, Malleable Iron Threaded Fittings Classes 150 and 300.
 - e. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
 - f. B16.9, Factory-Made Wrought Buttwelding Fittings.
 - g. B16.11, Forged Fittings, Socket-Welding and Threaded.
 - h. B16.15, Cast Copper Alloy Threaded Fittings Classes 125 and 250.
 - i. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
 - j. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
 - k. B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings Classes 150, 300, 600, 900, 1500, and 2500.
 - l. B16.25, Buttwelding Ends.
 - m. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300.
 - n. B31.1, Power Piping.
 - o. B31.3, Process Piping.
 - p. B31.9, Building Services Piping.
 - q. B36.10M, Welded and Seamless Wrought Steel Pipe.
 5. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Personal Qualification and Certification in Nondestructive Testing.

6. American Water Works Association (AWWA):
 - a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
 - d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - e. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 - f. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
 - g. C153/A21.53, Ductile-Iron Compact Fittings.
 - h. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
 - i. C606, Grooved and Shouldered Joints.
7. American Welding Society (AWS):
 - a. Brazing Handbook.
 - b. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
 - c. D1.1/D1.1M, Structural Welding Code - Steel.
 - d. QC1, Standard for AWS Certification of Welding Inspectors.
8. ASTM International (ASTM):
 - a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
 - b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - c. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
 - d. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
 - e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - f. A135/A135M, Standard Specification for Electric-Resistance-Welder Steel Pipe.
 - g. A139/A139M, Standard Specification for Electro-Fusion (Arc)-Welded Steel Pipe (NPS 4 Inches and Over).
 - h. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - i. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
 - j. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 - k. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.

- l. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
- m. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
- n. A197/A197M, Standard Specification for Cupola Malleable Iron.
- o. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
- p. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- q. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
- r. A276, Standard Specification for Stainless Steel Bars and Shapes.
- s. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
- t. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
- u. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
- v. A320/A320M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
- w. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
- x. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
- y. A403/A403M, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
- z. A409/A409M, Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
- aa. A536, Standard Specification for Ductile Iron Castings.
- bb. A563, Standard Specification for Carbon and Alloy Steel Nuts.
- cc. A587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
- dd. A743/A743M, Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
- ee. A744/A744M, Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
- ff. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.

- gg. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
- hh. B32, Standard Specification for Solder Metal.
- ii. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
- jj. B61, Standard Specification for Steam or Valve Bronze Castings.
- kk. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
- ll. B75/B75M, Standard Specification for Seamless Copper Tube.
- mm. B88, Standard Specification for Seamless Copper Water Tube.
- nn. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes.
- oo. B462, Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N10362, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, and UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
- pp. B464, Standard Specification for Welded UNS N08020 Alloy Pipe.
- qq. B474, Standard Specification for Electric Fusion Welded Nickel and Nickel Alloy Pipe.
- rr. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
- ss. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
- tt. D413, Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate.
- uu. D543, Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.
- vv. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
- ww. D1330, Standard Specification for Rubber Sheet Gaskets.
- xx. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
- yy. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- zz. D2000, Standard Classification System for Rubber Products in Automotive Applications.
- aaa. D2310, Standard Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

- bbb. D2464, Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 - ccc. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 - ddd. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 - eee. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
 - fff. D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
 - ggg. D2996, Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
 - hhh. D3222, Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
 - iii. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
 - jjj. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
 - kkk. D4894, Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials.
 - lll. D4895, Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced from Dispersion.
 - mmm. F423, Standard Specification for Polytetrafluoroethylene (PTFE) Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges.
 - nnn. F436, Standard Specification for Hardened Steel Washers.
 - ooo. F437, Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
 - ppp. F439, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
 - qqq. F441/F441M, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
 - rrr. F493, Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
 - sss. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - ttt. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
- 9. FM Global (FM).
 - 10. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43, Wrought and Fabricated Butt-Welding Fittings for Low-Pressure, Corrosion Resistant Applications.

11. NSF International (NSF):
 - a. ANSI 61: Drinking Water System Components - Health Effects.
 - b. ANSI 372: Drinking Water System Components - Lead Content.
12. National Electrical Manufacturers Association (NEMA): LI 1, Industrial Laminating Thermosetting Products.
13. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.02 DEFINITIONS

- A. Submerged or Wetted: Zone below elevation of:
 1. Top face of channel or wet well walls and cover slabs.
 2. Top face of aeration basin walkways.
 3. Liquid surface or within 3 feet above top of liquid surface.
 4. Top of tank wall or under tank cover.

1.03 DESIGN REQUIREMENTS

- A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:
 1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
 2. Building Service Piping: ASME B31.9, as applicable.
 - a. Building Roof Drainage Systems: Local plumbing code.
 3. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.
 4. Thrust Restraints:
 - a. Design for test pressure shown in Piping Schedule.
 - b. Allowable Soil Pressure: 1,000 pounds per square foot.
 - c. Low Pressure Pipelines:
 - 1) When bearing surface of the fitting against soil provides an area equal to or greater than area required for thrust restraint, concrete thrust blocks will not be required.
 - 2) Determine bearing area for fittings without thrust blocks by projected area of 70 percent of internal diameter multiplied by chord length for fitting centerline curve.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Fabricated Piping:
 - a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
 - b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
4. Thrust Blocks: Concrete quantity, bearing area on pipe, and fitting joint locations.
5. Dissimilar Buried Pipe Joints: Joint types and assembly drawings.
6. Pipe Corrosion Protection: Product data.
7. Anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Anchorage and Bracing Requirements.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements:
 - a. Pipe and fittings.
 - b. Factory applied resins and coatings.
2. Anchorage and bracing calculations as required by Section 01 60 01, Anchorage and Bracing Requirements.
3. Flanged Pipe and Fittings: Manufacturer's product data sheets for gaskets including torquing requirements and bolt tightening procedures.
4. Qualifications:
 - a. Nondestructive Testing Personnel: SNT-TC-1A Level II certification and qualifications.
 - b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
 - c. Welders:
 - 1) Continuity log for welders and welding operators.
 - 2) Welder qualification test records conducted by Contractor or manufacturer.

5. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
6. Nondestructive inspection and testing procedures.
7. Test logs.
8. Pipe coating applicator certification.
9. CWI inspection records and NDE test records.
10. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
 - a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
 - b. Calibrated instruments and equipment, and documented standard procedures for performing specified testing.
 - c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
 - d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
 - e. Verification Welding Inspector: AWS QC1 Certified.
2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D1.1/D1.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).
4. Contractor's CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

B. Quality Assurance: Special inspection to be provided by Owner and performed by independent inspection and testing agency for welding operations.

1. Note, the presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.

1.06 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and Section 01 66 00, Shipment, Protection and Storage., and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.

2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 PRODUCTS

2.01 GENERAL

- A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPING

- A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.
- B. Diameters Shown:
 1. Standardized Products: Nominal size.
 2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
 3. Cement-Lined Steel Pipe: Lining inside diameter.

2.03 JOINTS

- A. Grooved End System:
 1. Rigid type.
 2. Use of flexible grooved joints allowed where shown on Drawings or with prior approval by Engineer.
 3. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.

- B. Flanged Joints:
 - 1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
 - 2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.
- C. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.
- D. Mechanical Joint Anchor Gland Follower:
 - 1. Ductile iron anchor type, wedge action, with break-off tightening bolts. Gland followers that use set screws shall not be allowed.
 - 2. Thrust rated to 250 psi minimum.
 - 3. Rated operating deflection not less than:
 - a. 3 degrees for sizes through 12 inches.
 - b. 2 degrees for sizes 14 inches through 16 inches.
 - c. 1.5 degrees for sizes 18 inches through 24 inches.
 - d. 1 degree for sizes 30 inches through 48 inches.
 - 4. UL and FM approved.
- E. Flexible Mechanical Compression Joint Coupling:
 - 1. Stainless steel, ASTM A276, Type 305 bands.
 - 2. Manufacturers:
 - a. Pipeline Products Corp.
 - b. Fernco Joint Sealer Co.
- F. Mechanical connections of high-density polyethylene pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems shall be through-flanged connections consisting of the following:
 - 1. Polyethylene stub end thermally butt-fused to end of pipe.
 - 2. ASTM A240/A240M, Type 304 stainless steel backing flange, 125-pound, ASME B16.1 standard. Use insulating flanges where shown.
 - 3. Bolts and nuts of sufficient length to show a minimum of three complete threads when joint is made and tightened to manufacturer's standard. Retorque nuts after 4 hours.
 - 4. Gaskets as specified on Data Sheet.

2.04 GASKET LUBRICANT

- A. Lubricant shall be supplied by pipe manufacturer and no substitute or "or-equal" will be allowed.

2.05 PIPE CORROSION PROTECTION

- A. Coatings: See the Pipe Schedule in the Contract Documents. See also Section 09 90 00, Painting and Coating, for details of coating requirements.
- B. Heat Shrink Wrap:
 - 1. Type: Cross-linked polyolefin wrap or sleeve with mastic sealant.
 - 2. Manufacturer and Product: Raychem; WPC or TPS.
- C. Polyethylene Encasement (Bagging):
 - 1. Encasement Tube: Black polyethylene encasement tube, 8 mils minimum thickness, conforming to AWWA C105/A21.5, free of gels, streaks, pinholes, foreign matter, undispersed raw materials, and visible defects such as tears, blisters, and thinning at folds.
 - 2. Securing Tape: Thermoplastic tape, 8 mils minimum thickness, 1 inch wide, pressure sensitive adhesive face capable of bonding to metal, bituminous coating, and polyethylene encasement tube.
- D. Insulating Flanges, Couplings, and Unions:
 - 1. Materials:
 - a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.3 working pressure rating equal to or higher than that of joint and pipeline.
 - b. Galvanically compatible with piping.
 - c. Resistant for intended exposure, operating temperatures, and products in pipeline.
 - 2. Union Type, 2 Inches and Smaller:
 - a. Screwed or solder-joint.
 - b. O-ring sealed with molded and bonded insulation to body.
 - 3. Flange Type, 2-1/2 Inches and Larger:
 - a. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
 - b. Bolt insulating sleeves shall be provided full length between insulating washers.
 - c. Ensure fit-up of components of insulated flange assembly to provide a complete functioning installation.
 - d. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate insulating sleeves.
 - e. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of required washers, flanges, and gasket.

4. Flange Insulating Kits:
 - a. Gaskets: Full-face, Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
 - b. Insulating Sleeves: Full-length fiberglass reinforced epoxy (NEMA LI-1, G-10 grade).
 - c. Insulating Washers: Fiberglass-reinforced epoxy (NEMA LI-1, G-10 grade).
 - d. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
 - 1) Flange Diameters 36 Inches or Less: Provide two washers per bolt.
 - 2) Flange Diameters Larger Than 36 Inches: Provide four washers per bolt.
5. Manufacturers and Products:
 - a. Dielectric Flanges and Unions:
 - 1) GPT, Houston, TX.
 - 2) Advance Products and Systems, Lafayette, LA.
 - b. Insulating Couplings:
 - 1) Dresser; STAB-39.
 - 2) Baker Coupling Company, Inc.; Series 216.

2.06 THRUST BLOCKS

- A. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 THRUST TIES

- A. Steel Pipe or Aboveground Ductile Iron Pipe: Fabricated lugs and rods in accordance with details shown on Drawings.
- B. Buried Ductile Iron Pipe and Fittings: Unless otherwise approved, pipe and fittings shall be restrained by the use of proprietary restrained joints, or mechanical joints with a wedge style restraining gland as specified herein. Tie-rod attachments relying on clamp friction with pipe barrel to restrain thrust are unacceptable.

2.08 VENT AND DRAIN VALVES

- A. Pipeline 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless shown otherwise.
- B. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless shown otherwise.

2.09 FABRICATION

- A. Mark each pipe length on outside with the following:
 - 1. Size or diameter and class.
 - 2. Manufacturer's identification and pipe serial number.
 - 3. Location number on laying drawing.
 - 4. Date of manufacture.
- B. Code markings according to approved Shop Drawings.
- C. Shop fabricate flanged pipe in shop, not in field, and delivered to Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by manufacturer.

2.10 FINISHES

- A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.
- B. Galvanizing:
 - 1. Hot-dip applied, meeting requirements of ASTM A153/A153M.
 - 2. Electroplated zinc or cadmium plating is unacceptable.
 - 3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.
- B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

- A. See Piping Schedule and Section 09 90 00, Painting and Coating, for additional requirements.
- B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.
- C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

- D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions.

3.03 WELDING

- A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.
- B. Weld Identification: Keep paper record of which welder welded each joint.
- C. Pipe End Preparation:
 - 1. Machine Shaping: Preferred.
 - 2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
 - 3. Beveled Ends for Butt Welding: ASME B16.25.
- D. Surfaces:
 - 1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
 - 2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
 - 3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.
- E. Alignment and Spacing:
 - 1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
 - 2. Root Opening of Joint: As stated in qualified welding procedure.
 - 3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.
- F. Climatic Conditions:
 - 1. Do not perform welding if there is impingement of any rain, snow, sleet, or wind exceeding 5 mph on the weld area, or if ambient temperature is below 32 degrees F.
 - 2. Stainless Steel and Alloy Piping: If ambient is less than 32 degrees F, local preheating to a temperature warm to the hand is required.

- G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.
- H. Surface Defects: Chip or grind out those affecting soundness of weld.
- I. Weld Quality: Meet requirements of governing welding codes.

3.04 INSTALLATION—GENERAL

- A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.
- B. Remove foreign objects prior to assembly and installation.
- C. Flanged Joints:
 - 1. Install perpendicular to pipe centerline.
 - 2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
 - 3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
 - 4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
 - 5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
 - 6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
 - 7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
 - 8. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
 - 9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
 - 10. Manufacturer: Same as pipe manufacturer or grooved joint flange adapter manufacturer.
- D. Threaded and Coupled Joints:
 - 1. Conform to ASME B1.20.1.
 - 2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
 - 3. Countersink pipe ends, ream and clean chips and burrs after threading.
 - 4. Make connections with not more than three threads exposed.

5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.
- E. Grooved-End Joints:
1. Piping shall be grooved in accordance with manufacturer's latest published instructions and shall be accurately cut with tools conforming to coupling manufacturer's standards and to AWWA C606.
 2. Install grooved joint couplings and gaskets in accordance with manufacturer's latest published installation instructions.
- F. Soldered Joints:
1. Use only solder specified for particular service.
 2. Cut pipe ends square and remove fins and burrs.
 3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply noncorrosive flux to the male end only.
 4. Wipe excess solder from exterior of joint before hardened.
 5. Before soldering, remove stems and washers from solder joint valves.
- G. Brazed Joints for Refrigerant Piping:
1. Braze copper piping with silver solder complying with AWS A5.8/A5.8M.
 2. Construct joints according to AWS Brazing Handbook, Chapter Pipe and Tube.
 3. Inside of tubing and fittings shall be free of flux.
 4. Clean parts to be joined with emery cloth and keep hot until solder has penetrated the full depth of the fitting and extra flux has been expelled.
 5. Cool joints in air and remove flame marks and traces of flux.
 6. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel the air.
 7. 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.
- H. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 40 27 01, Process Piping Specialties.
- I. PVC Piping:
1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
 2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
 3. Do not thread Schedule 40 pipe.

J. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
 - a. General: As required for the type of joint to be made.
 - b. Rubber Gasketed Joints: Remove sharp edges or projections.
 - c. Push-On Joints: Bevel, as recommended by pipe manufacturer.
 - d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

K. High-Density Polyethylene Piping:

1. Join pipes, fittings, and flange connections by means of thermal butt-fusion.
2. Perform butt-fusion in accordance with pipe manufacturer's recommendations as to equipment and technique.
3. Special Precautions at Flanges: Polyethylene pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.

3.05 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 15, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

- F. Piping clearance, unless otherwise shown:
1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 3. From Adjacent Work: Minimum 1 inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
 5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
 6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
 7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.06 INSTALLATION—BURIED PIPE

- A. Joints:
1. Dissimilar Buried Pipes:
 - a. Provide flexible mechanical compression joints for pressure pipe.
 - b. Provide concrete closure collar for gravity and low pressure (maximum 10 psi) piping or as shown.
 2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown.
- B. Placement:
1. Keep trench dry until pipe laying and joining are completed.
 2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.15, Trench Backfill.
 3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
 4. Measure for grade at pipe invert, not at top of pipe.
 5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
 6. Prevent foreign material from entering pipe during placement.

7. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in direction of laying.
9. Install closure sections and adapters for gravity piping at locations where pipe laying changes direction.
10. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
 - a. Shorter pipe lengths.
 - b. Special mitered joints.
 - c. Standard or special fabricated bends.
11. After joint has been made, check pipe alignment and grade.
12. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
13. Prevent uplift and floating of pipe prior to backfilling.

C. PVC or HDPE Pipe Placement:

1. Lay pipe snaking from one side of trench to other.
2. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.
3. Do not lay pipe when temperature is below 40 degrees F, or above 90 degrees F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:

1. Deflection from Horizontal Line, Except PVC or HDPE: Maximum 2 inches.
2. Deflection From Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.
4. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.07 INSTALLATION—CONCRETE ENCASED

- A. Provide reinforced concrete pipe encasement where shown on Drawings and where otherwise required. Some piping may be required to be concrete encased for pipe strength requirements that are included in the Specifications. Piping under and within the influence of buildings, utility trenches, vaults, slabs, and other structures shall be concrete encased. See details on Drawings for encasement requirements.

- B. Where concrete encased piping crosses structure construction and expansion joints, provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

3.08 PIPE CORROSION PROTECTION

A. Ductile Iron Pipe:

- 1. Exposed: As specified in Section 09 90 00, Painting and Coating, and as shown in Piping Schedule.
- 2. Buried: Wrap with polyethylene bagging.
- 3. Submerged or Embedded: Coat with epoxy as specified in Section 09 90 00, Painting and Coating.

B. Carbon Steel Pipe:

- 1. Exposed: As specified in Section 09 90 00, Painting and Coating.
- 2. Buried:
 - a. Pipe: Wrap with tape coating system as specified in Section 09 90 00, Painting and Coating.
 - b. Joints: Wrap with tape coating system as specified in Section 09 90 00, Painting and Coating, or heat shrink wrap as specified herein.
- 3. Submerged or Embedded: Shop coat with epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service, use NSF/ANSI 61 approved epoxy.

C. Copper Pipe:

- 1. Exposed: As specified in Section 09 90 00, Painting and Coating.
- 2. Buried:
 - a. Pipe: Wrap with tape coating system as specified in Section 09 90 00, Painting and Coating.
 - b. Joints: Wrap with tape coating system as specified in Section 09 90 00, Painting and Coating, or heat shrink wrap as specified herein.

D. PVC Pipe, Exposed: As specified in Section 09 90 00, Painting and Coating.

E. Piping Accessories:

- 1. Exposed:
 - a. Field paint black and galvanized steel, brass, copper, and bronze piping components as specified in Section 09 90 00, Painting and Coating, as applicable to base metal material.

- b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.
 2. Buried:
 - a. Ferrous Metal and Stainless Steel Components: Coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating.
 - b. Bolts, Nuts, and Similar Items: Coat with bituminous paint.
 - c. Flexible Couplings, Grooved Couplings, and Similar Items: Wrap with heat shrink wrap.
 - d. Buried Valves and Similar Elements on Wrapped Pipelines: Coat with bituminous paint and wrap entire valve in polyethylene encasement.
- F. Polyethylene Encasement: Install in accordance with AWWA C105/A21.5 and manufacturer's instructions.
- G. Tape Coating System: As specified in Section 09 90 00, Painting and Coating.
- H. Heat Shrink Wrap: Apply in accordance with manufacturer's instructions to surfaces that are cleaned, prepared, and primed.
- I. Insulating Flanges, Couplings, and Unions:
 1. Applications:
 - a. Dissimilar metal piping connections.
 - b. Cathodically protected piping penetration to watertight structures.
 - c. Submerged to unsubmerged metallic piping connections.
 - d. Connections to existing metallic pipe.
 - e. Where required for electrically insulated connection.
 2. Pipe Installation:
 - a. Insulating joints connecting immersed piping to nonimmersed piping shall be installed above maximum water surface elevation.
 - b. Submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete shall be isolated from the concrete reinforcement steel.
 - c. Align and install insulating joints as shown on the Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.
- J. Pipe Bonding for Buried Piping: As specified in Section 26 42 01, Pipe Bonding and Test Stations.

3.09 THRUST RESTRAINT

A. Location:

1. Buried Piping: Where shown and where required to restrain force developed at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist because of hydrostatic testing and normal operating pressure.
2. Exposed Piping: At all joints in piping.

B. Preferred Method of Thrust Restraint for Buried DI Pipe: Unless otherwise approved, use proprietary restrained joints or mechanical joints with mechanical joint anchor gland follower.

C. Thrust Ties:

1. Steel Pipe: Attach with lugs fabricated in accordance with details shown on Drawings
2. Ductile Iron Pipe: Attach with socket clamps anchored against grooved joint coupling or flange.
3. Flanged Coupling Adapters: For exposed installations, install manufacturer's anchor studs through coupling sleeve or use dismantling joints.

D. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint manufacturer's adapter gland follower and pipe end retainer, or mechanical joint anchor gland follower.

E. Thrust Blocking (with prior approval only):

1. Place between undisturbed ground and fitting to be anchored.
2. Quantity of Concrete: Sufficient to cover bearing area on pipe and provide required soil bearing area as shown.
3. Place blocking so that pipe and fitting joints will be accessible for repairs.
4. Place concrete in accordance with Section 03 30 00, Cast-in-Place Concrete.

3.10 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.11 BRANCH CONNECTIONS

- A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.
- B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.
- C. Threaded Pipe Tap Connections:
 - 1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.
 - 2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.
 - 3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.12 VENTS AND DRAINS

- A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines at all low and high point locations.

3.13 INSULATION

- A. See Section 40 42 13, Process Piping Insulation.

3.14 HEAT TRACING

- A. See Section 40 05 33, Pipe Heat Tracing.

3.15 FIELD FINISHING

- A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.
- B. As specified in Section 09 90 00, Painting and Coating.

3.16 PIPE IDENTIFICATION

- A. As specified in Section 09 90 00, Painting and Coating.

3.17 FIELD QUALITY CONTROL

- A. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.

B. Minimum Duties of Welding Inspector:

1. Job material verification and storage.
2. Qualification of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code ASME B31.3 for Normal Fluid Service.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.18 CLEANING

- A. Following assembly and testing, and prior to final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.
- B. Blow clean of loose debris plant process air and instrument air lines with compressed air at 4,000 fpm; do not flush with water.
- C. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.
- D. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.
- E. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.19 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification:

1. Data Sheets.

Number	Title
40 27 00.01	Cement-Mortar-Lined Ductile Iron Pipe and Fittings
40 27 00.03	Carbon Steel Pipe and Fittings—General Service
40 27 00.04	Welded Steel Pipe and Fittings
40 27 00.07	Galvanized Steel Pipe and Malleable Iron Fittings
40 27 00.08	Stainless Steel Pipe and Fittings—General Service
40 27 00.10	Polyvinyl Chloride (PVC) Pipe and Fittings
40 27 00.13	Copper and Copper Alloy Pipe, Tubing, and Fittings

END OF SECTION

SECTION 40 27 00.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	Description
General	<p>Materials in contact with potable water shall conform to NSF 61 acceptance.</p> <p>Pipe manufacturer shall submit certification that source manufacturing facility has been producing ductile iron pipe of the specified diameters, dimensions, and standards for a period of not less than 10 years. Testing of pipe required by AWWA A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. Pipe shall be handled during manufacture and shipped without nesting (without insertion of one pipe inside another).</p>
Pipe	<p>Buried Liquid Service Using Mechanical or Proprietary Restrained Joints: AWWA C111/A21.11, and AWWA C151/A21.51, pressure class conforming to Table 5 and Table 7 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron and shall be wedge style restrained glands where needed to resist thrust in the pipe.</p> <p>Exposed Pipe Using Grooved End and Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.</p>
Lining	Cement-mortar: AWWA C104/A21.4.
Fittings	<p>Lined and coated same as pipe.</p> <p>Mechanical: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 ductile iron, 250 psi minimum working pressure. Follower glands shall be ductile iron, and shall be wedge style restrained glands where needed to resist thrust in the pipe.</p> <p>Proprietary Restrained: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Restraint shall be achieved with removable metal elements fitted between a welded bar on the pipe barrel and the inside of the joint bell or fitting sizes smaller than 16 inches may be mechanical joint, restrained by anchor gland followers, ductile iron anchor type, wedge action, with break-off tightening bolts. Assembled joints shall be rated for deflection in operation at rated pressure. Rated deflection shall be not less than 1-1/2 degrees for 36-inch and smaller pipe. Rated deflection shall be not less than 1/2 degree for 42-inch and larger pipe. Clow Corp., American Cast Iron Pipe Co., U.S. Pipe. Restrained joints relying on metal teeth molded into the gasket to prevent joint separation under pressure will not be accepted.</p>

SECTION 40 27 00.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	Description
	<p>Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure; Victaulic.</p> <p>Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face. Gray cast iron will not be allowed.</p>
Joints	<p>Mechanical: 250 psi minimum working pressure, with wedge style restrained glands where needed to resist thrust in the pipe.</p> <p>Proprietary Restrained: 150 psi minimum working pressure. Clow Corp., Super-Lock; American Cast Iron Pipe Co., Flex-Ring or Lok-Ring; U.S. Pipe, TR Flex.</p> <p>Grooved End: Rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure; Victaulic.</p> <p>Flange: Class 125 flat face, ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed.</p> <p>Branch connections 3 inches and smaller shall be made with service saddles as specified in Section 40 27 01, Process Piping Specialties.</p>
Couplings	<p>Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic.</p> <p>Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic.</p>
Bolting	<p>Mechanical, Proprietary Restrained, and Grooved End Joints: Manufacturer's standard.</p> <p>Class 125 Flat-Faced Flange: ASTM A307, Grade A carbon steel hex head bolts, ASTM A563, Grade A carbon steel hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.</p> <p>Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts; ASTM A194/A194M, Grade 8M hex nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.</p>

SECTION 40 27 00.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	Description
Gaskets	<p>General: Gaskets in contact with potable water shall be NSF 61 certified.</p> <p>Mechanical and Proprietary Restrained Joints; Water and Sewage Service: Rubber conforming to AWWA C111/A21.11.</p> <p>Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606.</p> <p>Flanged, Water and Sewage Services: 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D2000 4CA 415 A25 B35 C32 EA14 F19.</p> <p>Full face for Class 125 flat-faced flanges, flat-ring type for Class 250 raised-face flanges. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange.</p> <p>Gasket pressure rating to equal or exceed the system hydrostatic test pressure.</p>
Joint Lubricant	Manufacturer's standard.

END OF SECTION

SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	Size	Description
Pipe	<p>All</p> <p>Screwed: 2" & smaller</p> <p>Welded: 2-1/2" thru 10" 12" thru 16" 18" thru 24"</p> <p>Grooved: 2-1/2" thru 6" 8" thru 12" inch 14"</p>	<p>Black carbon steel, ASTM A106/A106M, Grade B seamless or ASTM A53/A53M, Grade B seamless or ERW. Threaded, butt-welded, grooved end, and flanged joints:</p> <p>Schedule 40.</p> <p>Schedule 40.</p> <p>Schedule 30.</p> <p>Schedule 20.</p> <p>Schedule 40.</p> <p>Schedule 30.</p> <p>Standard weight.</p>
Joints	<p>2" & smaller</p> <p>2-1/2" & larger</p>	<p>Threaded or flanged at valves and equipment or grooved end meeting the requirements of AWWA C606.</p> <p>Butt-welded or flanged at valves and equipment, or grooved end meeting the requirements of AWWA C606.</p>
Fittings	2" & smaller	<p>Threaded: 150- or 300-pound malleable iron, ASTM A197/A197M or ASTM A47/A47M, dimensions in accordance with ASME B16.3. Fire sprinkler fittings to be UL listed.</p> <p>Grooved End: Malleable iron ASTM A47/A47M or ductile iron ASTM A536, grooved ends to accept couplings without field preparation. Victaulic Co.; Anvil International, Inc., Gruvlok.</p>

SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	Size	Description
	2-1/2" & larger	<p>Butt Welded: Wrought carbon steel butt-welding, ASTM A234/A234M, Grade WPB meeting the requirements of ASME B16.9; fitting wall thickness to match adjoining pipe; long radius elbows unless shown otherwise.</p> <p>Grooved End: Malleable iron ASTM A47/A47M, ductile iron ASTM A536, forged steel ASTM A234/A234M, or factory fabricated from ASTM A53/A53M pipe. Grooved ends to accept couplings without field preparation. Victaulic Co.; Anvil International, Inc., Gruvlok; Shurjoint Piping Products.</p>
Branch Connections	2" & smaller	<p>For threaded pipe: Threaded, straight, or reducing tees in conformance with Fittings specified above.</p> <p>For welded or grooved pipe, use threadolet.</p>
	2-1/2" & larger	<p>Butt-welding or grooved end tee in conformance with Fittings specified above.</p>
Flanges	2" & smaller	<p>Forged carbon steel, ASTM A105/A105M, Grade II, ASME B16.5 Class 150 or Class 300 socket-weld or threaded, 1/16-inch raised face.</p>
	2-1/2" & larger	<p>Butt-Welded Systems: Forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150 or Class 300 slip-on or welding neck, 1/16-inch raised face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings. Weld slip-on flanges inside and outside.</p> <p>Grooved End Adapter Flange: Malleable iron ASTM A47/A47M or ductile iron ASTM A536. Victaulic Style 741 or 743; Anvil International, Inc., Gruvlok Figure 7012 or 7013; Shurjoint Model 7041-A. Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.</p>

SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	Size	Description
		Cast Iron Mating Flange: AWWA C207, Class D or E, hub or ring type to mate with ASME B16.1, Class 125 cast-iron flange. AWWA C207 Class F hub type or ASTM A105/A105M, ASME B16.5 Class 300 to mate with ASME B16.1 Class 250 cast-iron flange.
Unions	2" & smaller	Threaded malleable iron, ASTM A197/A197 or ASTM A47/A47M, 150- or 300-pound WOG, meeting the requirements of ASME B16.3.
Couplings	2-1/2" & larger	Grooved End: Rigid joint malleable iron, ASTM A47/A47M or ductile iron, ASTM A536. Victaulic Co.; Anvil International, Inc., Gruvlok; Shurjoint Piping Products. Screwed End: Malleable iron, ASTM A197/A197M or ASTM A47/A47M.
Bolting	All	Flanges: Carbon steel ASTM A307, Grade A hex head bolts; ASTM A563, Grade A hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. When mating flange on equipment is cast iron and gasket is flat ring, provide ASTM A307, Grade B hex head bolts; ASTM A563, Grade A heavy hex nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.

SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	Size	Description
		<p>Grooved End Couplings: Carbon steel, ASTM A183 bolts and nuts, 110,000 psi minimum tensile strength.</p> <p>Flanged Joints in Sumps, Wet Wells, and Submerged, Wetted and Buried Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts; ASTM A194/A194M, Grade 8M hex nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.</p>
Gaskets	All flanges	<p>Water and Air Services: 1/16-inch-thick, compressed inorganic fiber with nitrile binder, rated 400 degrees F. continuous.</p> <p>Blind flanges shall be gasketed covering the entire inside face with the gasket cemented to the blind flange.</p> <p>Grooved Couplings: EPDM per ASTM D2000 for water and oil-free air to 230 degrees F, nitrile for oil vapor in air and oil services to 180 degrees F.</p>
Thread Lubricant	2" & smaller	General Service: 100 percent virgin PTFE Teflon tape.

END OF SECTION

SECTION 40 27 00.04 WELDED STEEL PIPE AND FITTINGS	
Item	Description
Pipe	Carbon steel plate per ASTM A283/A283M, Grade C or ASTM A285/A285M Grade C, fabricated in accordance with AWWA C200, straight seam, thickness designed for 66 percent of minimum yield stress at hydrostatic test pressure, minimum thickness 1/4-inch.
Linings	As indicated on the Piping Schedule. Cement-Mortar: AWWA C205, applied by pipe manufacturer.
Coatings	As indicated on the Piping Schedule.
Interior Bracing	60 degree spiders set 2 feet from each end and at the one-third points capable of withstanding backfill loadings. Bracing at one-third point not required for sections less than 10 feet in length.
Joints	Exposed Piping: Butt weld AWWA C200 or flanged.
Fittings	Fabricated: Carbon steel fabricated from pipe in accordance with AWWA C208; elbows to have a 22.5-degree maximum miter section angle, minimum of three sections; wyes, tees, crosses, and outlets to be reinforced in accordance with AWWA M-11. Forged: Butt-welding fittings, ASTM A234/A234M, Grade WPB meeting the requirements of ANSI B16.9. Fitting wall thickness to match adjoining pipe. Elbows to be long radius unless shown otherwise.
Flanges	AWWA C207, Class D (150 psi), hub or ring type.
Bolting	Carbon steel ASTM A307, Grade A hex head bolts and ASTM A563, Grade A hex head nuts.
Gaskets	Flanged, Water, Sewage, and Low Pressure Air Service: 1/8-inch thick, unless otherwise specified, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 300 degrees F, conforming to ANSI B16.21 and ASTM D1330 Steam Grade. Ring gaskets shall not be permitted. Blind flanges shall be gasketed covering the entire inside face with the gasket cemented to the blind flange.

END OF SECTION

SECTION 40 27 00.07 GALVANIZED STEEL PIPE AND MALLEABLE IRON FITTINGS		
Item	Size	Description
Pipe	2" & smaller 2-1/2" thru 6" 8" thru 12" 14"	Galvanized carbon steel, ASTM A106, Grade B seamless or ASTM A53, Grade B seamless or ERW. Schedule 80. Schedule 40. Schedule 30. Standard weight.
Joints	2" & smaller 2-1/2" & larger	Threaded or flanged at valves and equipment, or grooved end meeting requirements of AWWA C606. Flanged at valves and equipment, or grooved end meeting requirements of AWWA C606.
Fittings		Threaded: 150- or 300-pound malleable iron, ASTM A197 or ASTM A47, dimensions in accordance with ASME B16.3. Grooved End: Malleable iron ASTM A47 or ductile iron ASTM A536, 250 psi working pressure, grooved ends to accept couplings without field preparation. Victaulic; Anvil International, Inc., Gruvlok.
Branch Connections	2" & smaller 2-1/2" & larger	Tee or reducing tee in conformance with Fittings above, galvanized 2,000-pound WOG threadolet or welding boss; galvanize after welding. Branch Same Size as Run: Grooved end tee in accordance with Fittings above. Branch One or More Sizes Smaller Than Run: grooved end reducing tee in accordance with Fittings above.
Flanges		Galvanized forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150 or Class 300, threaded, 1/16-inch raised face. Grooved end adapter flange, malleable iron ASTM A47 or ductile iron ASTM A536. Victaulic; Anvil International, Inc., Gruvlok.

SECTION 40 27 00.07 GALVANIZED STEEL PIPE AND MALLEABLE IRON FITTINGS		
Item	Size	Description
Unions		Threaded malleable iron, ASTM A197 or ASTM A47, 300-pound WOG, brass to iron seat, meeting the requirements of ASME B16.3.
Couplings		Grooved End: Rigid joint malleable iron, ASTM A47 or ductile iron, ASTM A536, 250 psi working pressure. Victaulic; Anvil International, Inc., Gruvlok.
Plugs		Forged carbon steel, ASTM A181/A181M, Grade II, round head, threaded, galvanized.
Bolting		Grooved End Couplings: Carbon steel, ASTM A183 bolts and nuts, 110,000 psi minimum tensile strength. Flanges: Carbon steel ASTM A307, Grade A hex head bolts and ASTM A563, Grade A hex head nuts.
Gaskets	All flanges Grooved end couplings	Flanged, Water and Sewage Service: 1/8 inch thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 250 degrees F. continuous and conforming to ASME B16.21 and ASTM D1330, Steam Grade. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange. EPDM or chlorinated butyl per ASTM D2000 for water, and air to 230 degrees F, dimensions conforming to AWWA C606.
Thread Lubricant	2" & smaller	Teflon tape or joint compound that is insoluble in water.

END OF SECTION

SECTION 40 27 00.08 STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	Size	Description
Pipe	2-1/2" & smaller	Schedule 40S: ASTM A312/A312M, Type 304 seamless, pickled and passivated.
	3" thru 6"	Schedule 10S: ASTM A778, "as-welded" grade, Type 304L, pickled and passivated.
	8" & larger	Schedule 5S: ASTM A778, "as-welded" grade, Type 304L, pickled and passivated.
Joints	1-1/2" & smaller	Threaded or flanged at equipment as required or shown.
	2" & larger	Butt-welded or flanged at valves and equipment.
Fittings	1-1/2" & smaller	Threaded: Forged 1,000 CWP minimum, ASTM A182/A182M, Grade F304 or cast Class 150, ASTM A351/A351M, Grade CF8/304.
	2" & 2-1/2"	Butt Welded: ASTM A403/A403M, Grade WP304L conforming to ASME B16.9 and MSS SP 43, annealed, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	3" & larger	Butt-Welded: ASTM A774/A774M Grade 304L conforming to MSS SP 43, "as-welded" grade, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
Branch Connections	1-1/2" & smaller	Tee or reducing tee in conformance with fittings above.
	2" & larger	Butt-welding tee or reducing tee in accordance with fittings above.
Flanges	All	Forged Stainless Steel: ASTM A182/A182M, Grade F304L ASME B16.5 Class 150 or Class 300, slip-on weld neck or raised face. Weld slip-on flanges inside and outside.

SECTION 40 27 00.08 STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	Size	Description
Unions	2" & smaller	Threaded Forged: ASTM A182/A182M, Grade F304, 2,000-pound or 3,000-pound WOG, integral ground seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe.
Bolting	All	Forged Flanges: Type 316 stainless steel, ASTM A320/A320M Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	All Flanges	Flanged, Water, Hot Air, Fuel Gas and Sewage Services: 1/8 inch thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 250 degrees F. continuous and conforming to ASME B16.21 and ASTM D1330, Steam Grade. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange.
Thread Lubricant	2" & smaller	General Service: 100 percent virgin PTFE Teflon tape.

END OF SECTION

SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	Size	Description
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	All (EXP) <4" (BUR) =>4" (BUR) =>4" (BUR)	Schedule 40 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded Nipples: Schedule 80 PVC. Buried Pressure Pipe – AWWA C900, pressure class 150. Buried Gravity Pipe – ASTM D3034SDR less than 35, except cell classification shall be 12454-B or 12454-C as defined in ASTM D1784.
Fittings	All (EXP) <4" (BUR) =>4" (BUR) =>4" (BUR)	Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection. Buried Pressure Pipe – Mechanical joint, AWWA C110/A21.10, AWWA C11/A21.11 and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Buried Gravity Pipe – PVC, gasketed, push-on style.
Joints	All (EXP) <4" (BUR) =>4" (BUR)	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly. Rubber gasketed, push-on style. Conform to AWWA C900 for pressure pipe.
Flanges	All	One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling

SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	Size	Description
Bolting	All	<p>Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.</p> <p>With Raised Face Mating Flange: Carbon steel ASTM A307 Grade B square head bolts, ASTM A563 Grade A heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.</p>
Gaskets	<p>All (EXP) <4" (BUR)</p> <p>=>4" (BUR)</p>	<p>Flat Face Mating Flange: Full faced 1/8-inch-thick ethylene propylene (EPR) rubber.</p> <p>Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EPR) rubber with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.</p> <p>In accordance with C900 for pressure pipe and with ASTM F477 for gravity pipe.</p>
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer.
Thread Lubricant	All	Teflon Tape.

END OF SECTION

SECTION 40 27 00.13 COPPER AND COPPER ALLOY PIPE, TUBING, AND FITTINGS	
Item	Description
General	Materials in contact with potable water shall conform to NSF 61 acceptance.
Tubing	Seamless, conforming to ASTM B88 as follows: Compressed air serviceType L, hard drawn
Fittings	ASTM B75 commercially pure wrought copper, socket joint, dimensions conforming to ASME B16.22.
Flanges	Class 150, ASTM B75 commercially pure wrought copper, socket joint, ASME B16.24 standard.
Bolting	ASTM A307, carbon steel, Grade A hex head bolts, ASTM A563 Grade A hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	1/16-inch-thick nonasbestos compression type, full face, Cranite, John Manville.
Solder	Joints 2-1/2 Inch and Smaller: Wire solder (95 percent tin), conforming to ASTM B32 Alloy Grade Sn95. Do not use cored solder. Joints Larger Than 2-1/2 Inch: Wire solder, melt range approximately 440 degrees F to 660 degrees F, conforming to ASTM B32 Alloy Grade HB or HN. Do not use cored solder.

END OF SECTION

SECTION 40 27 01
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
 - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
 - b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
2. American Water Works Association (AWWA):
 - a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
 - b. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
 - c. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
 - d. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
 - e. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
 - f. Manual M11, Steel Pipe—A Guide for Design and Installation.
3. ASTM International (ASTM):
 - a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - b. A276, Standard Specification for Stainless Steel Bars and Shapes.
4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
5. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).

- B. Informational Submittals:
 - 1. Coupling Harness:
 - a. Details, ratings, calculations and test reports for thrust restraints relying on welded bars or rings.
 - b. Weld procedure qualifications.
- C. Operation and Maintenance Data as specified in Section 01 76 00, Operating and Maintenance Information.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.
- B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.
- C. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 - 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 CONNECTORS

- A. Elastomer Bellows Connector:
 - 1. Type: Fabricated spool, with single filled arch.
 - 2. Materials: Nitrile tube and wrap-applied neoprene cover.
 - 3. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with full elastomer face and steel retaining rings.
 - 4. Working Pressure Rating: 100 psig, minimum, at 180 degrees F..
 - 5. Thrust Restraint: Control rods to limit travel of elongation and compression.
 - 6. Manufacturers and Products:
 - a. Goodall Rubber Co.; Specification 1462.
 - b. Garlock; Style 204.

- c. Unisource Manufacturing, Inc.; Style 1501.
- d. Proco Products, Inc.; Series 220.

B. Closure Collar Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.03 COUPLINGS

A. General:

- 1. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
- 2. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.
- 3. Couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213.
- 4. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11 or as shown on Drawings.
- 5. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.

B. Flexible Sleeve Type Coupling:

- 1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1) Dresser Piping Specialties; Style 38.
 - 2) Smith-Blair, Inc.; Style 411.
 - b. Ductile Iron Pipe:
 - 1) Dresser Piping Specialties; Style 253.
 - 2) Smith-Blair, Inc.; Style 441.

C. Transition Coupling for Steel Pipe:

- 1. Manufacturers and Products:
 - a. Dresser Piping Specialties; Style 162.
 - b. Smith-Blair, Inc.; Style 413.

D. Flanged Coupling Adapter:

- 1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1) Dresser Piping Specialties; Style 128.
 - 2) Smith-Blair, Inc.; Style 913.

- b. Ductile Iron Pipe:
 - 1) Dresser Piping Specialties; Style 128.
 - 2) Smith-Blair, Inc.; Style 912.

- E. Restrained Flange Adapter:
 - 1. Pressure Rating:
 - a. Minimum Working Pressure Rating: Not less than 150 psi.
 - b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer's proof testing.
 - 2. Thrust Restraint:
 - a. Provide hardened steel wedges that bear against and engage outer pipe surface, and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
 - b. Products employing set screws that bear directly on pipe will not be acceptable.
 - 3. Manufacturer and Product: EBAA Iron Sales Co.; Mega-Flange.

- F. Restrained Dismantling Joints:
 - 1. Pressure Rating:
 - a. Minimum working pressure rating shall not be less than rating of the connecting flange.
 - b. Proof testing shall conform to requirements of AWWA C219 for bolted couplings.
 - 2. Manufacturers and Products:
 - a. Dresser Piping Specialties; Style 131.
 - b. Smith Blair, Inc.; Model 975.

2.04 EXPANSION JOINTS

- A. Elastomer Bellows:
 - 1. Type: Reinforced molded arches. Number of arches as required to achieve the movements listed below.
 - 2. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with split galvanized steel retaining rings.
 - 3. Washers: Over retaining rings to help provide leak-proof joint under test pressure.
 - 4. Thrust Protection: Control rods to protect the bellows from overextension.
 - 5. Bellows Arch Lining and Cover: EPDM.
 - 6. Rated Temperature: 250 degrees F.

7. Rated Deflection and Pressure:
 - a. Axial Compression: 3 inches, minimum.
 - b. Axial Extension: 2 inches, minimum.
 - c. Lateral Deflection: 2 inches, minimum.
 - d. Rated Pressure: 100 psig, minimum.
8. Manufacturers and Products:
 - a. Mercer; Invincible Style 500.
 - b. Proco Products, Inc.; Series 231.

2.05 SEAL WATER HOSE

- A. Polyethylene tubing, 100 psig minimum working pressure at 70 degrees F, 3/8 inch with male NPT ends or as required to connect to equipment, not to exceed 3-foot length.

2.06 SERVICE SADDLES

- A. Double-Strap Iron:
 1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
 2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
 3. Taps: Iron pipe threads.
 4. Materials:
 - a. Body: Malleable or ductile iron.
 - b. Straps: Galvanized steel.
 - c. Hex Nuts and Washers: Steel.
 - d. Seal: Rubber.
 5. Manufacturers and Products:
 - a. Smith-Blair; Series 313 or 366.
 - b. Dresser; Style 91.

2.07 FLANGED SADDLE OUTLET

- A. Materials:
 1. Straps: Alloy steel with 3/4-inch threaded ends.
 2. Seal: O-Ring SBR rubber gasket.
 3. Compatible with ductile iron pipe.
- B. Connection: AWWA C110/A21.10 flange.
- C. Pressure Rating: Capable of withstanding 250 psi internal pressure without leakage over stressing.

D. Manufacturer and Product:

1. American Ductile Iron; Outlet/Tapping Saddle.
2. US Pipe; Saddle Outlet.

2.08 PIPE SLEEVES

A. Steel Pipe Sleeve:

1. Minimum Thickness: 3/16 inch.
2. Seep Ring:
 - a. Center steel flange for water stoppage on sleeves in exterior or water-bearing walls, 3/16-inch minimum thickness.
 - b. Outside Diameter: Unless otherwise shown, 3 inches greater than pipe sleeve outside diameter.
 - c. Continuously fillet weld on each side all around.
3. Factory Finish:
 - a. Galvanizing:
 - 1) Hot-dip applied, meeting requirements of ASTM A153/A153M.
 - 2) Electroplated zinc or cadmium plating is unacceptable.
 - b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Molded Polyethylene Pipe Sleeve:

1. Molded HDPE with integral water stop ring not less than 3 inches larger than sleeve.
2. Provided with end caps for support during concrete placement.
3. Manufacturer and Product: Century-Line, Model CS sleeves as manufactured by PSI-Thunderline/Link-Seal.

C. Insulated and Encased Pipe Sleeve:

1. Manufacturer and Product: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.

D. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication:
 - a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
 - b. Pressure plates shall be reinforced nylon polymer.

3. Size: According to manufacturer's instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 20 feet of water.
4. Manufacturers and Products:
 - a. Thunderline Corp., Link-Seal Division.
 - b. Proco; Pen-Seal.

2.09 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Ductile Iron Wall Pipe:

1. Diameter, Lining, and Ends: Same as connecting ductile iron pipe.
2. Thickness: Equal to or greater than remainder of pipe in line.
3. Fittings: In accordance with applicable Pipe Data Sheet.
4. Thrust Collars:
 - a. Rated for thrust load developed at 250 psi.
 - b. Safety Factor: 2, minimum.
 - c. Material and Construction: Ductile iron or cast iron, cast integral with wall pipe wherever possible, or thrust rated, welded attachment to wall pipe.
5. Manufacturers:
 - a. American Cast Iron Pipe Co.
 - b. U.S. Pipe and Foundry Co.

B. Steel or Stainless Steel Wall Pipe:

1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
2. Lining: Same as connecting pipe.
3. Thrust Collar:
 - a. Outside Diameter: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe.
 - b. Continuously fillet welded on each side all around.

2.10 MISCELLANEOUS SPECIALTIES

A. Strainers, Water Service, 2 Inches and Smaller:

1. Type: Bronze body, Y-pattern, 200 psi nonshock rated, with screwed gasketed bronze cap.
2. Screen: Heavy-gauge Type 304 stainless steel or monel, 20-mesh.
3. Manufacturers and Products:
 - a. Armstrong International; Inc.; Model F.
 - b. Mueller Steam Specialty; Model 351M.

- B. Strainers, Water Service, 2-1/2 Inches and Larger:
1. Type: Cast iron or ductile iron body, Y-pattern, 175 psi nonshock rated, with flanged gasketed iron cap.
 2. Screen: Heavy-gauge Type 316 stainless steel, 0.045-inch perforations.
 3. Manufacturer and Product: Armstrong International, Inc.; Model A7FL 125.
- C. Water Hose:
1. Furnish one 50-foot lengths of 1-inch and two 50-foot lengths of 1-1/2-inch rubber hose. EPDM black cover and EPDM tube, reinforced with two textile braids. Provide each length with brass male and female NST hose thread couplings to fit hose nozzle and hose valve.
 2. Rated minimum working pressure of 200 psi.
 3. Manufacturers:
 - a. Goodyear.
 - b. Boston.
- D. Hose Nozzles:
1. Furnish one 1-inch and two 1-1/2-inch cast brass, satin finish, nozzles with adjustable fog, straight-stream, and shut-off feature and rubber bumper. Provide nozzles with female NST hose thread.
 2. Manufacturers:
 - a. Croker.
 - b. Elkhart.
- E. Pump Seal Water Sight Flow Indicators:
1. Bronze body, 3/8-inch, horizontal, ball action with tempered glass.
 2. Rated 125 psi with NPT screwed ends.
 3. Operate with a minimum flow of 0.25 gpm.
 4. Manufacturers and Products:
 - a. Eugene Ernst Co.; Series E-57-4.
 - b. Jacoby Tarbox Co.
- F. Spray Nozzles
1. Type 1 (Aeration Basins – Effluent Box):
 - a. Spray Pattern: Full cone.
 - b. Spray Angle: 60 degrees.
 - c. Material: Type 316 stainless steel.
 - d. Orifice Diameter: 1/2 inch.
 - e. Capacity: 35 gpm at 80 psi.

- f. Size: 1/2-inch NPT.
- g. Manufacturer and Product:
 - 1) Spraying Systems Co.; Model Series FullJet.
 - 2) Or equal.
- 2. Type 2: Aeration Basins:
 - a. Spray Pattern: Narrow angle, high impact.
 - b. Spray Angle: 35 degrees at 40 psi.
 - c. Material: Type 316 stainless steel.
 - d. Orifice Diameter: 11/64 inch.
 - e. Capacity: 9.5 gpm at 100 psi.
 - f. Size: 1/2-inch NPT.
 - g. Manufacturer and Product:
 - 1) Spraying Systems Co.; Model Series FlatJet.
 - 2) Or equal.

PART 3 EXECUTION

3.01 GENERAL

- A. Provide accessibility to piping specialties for control and maintenance.

3.02 PIPING FLEXIBILITY PROVISIONS

- A. General:
 - 1. Thrust restraint shall be provided as specified in Section 40 27 00, Process Piping—General.
 - 2. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.
- B. Flexible Joints at Concrete Backfill or Encasement: Install within 18 inches or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.
- C. Flexible Joints at Concrete Structures:
 - 1. Install 18 inches or less from face of structures; joint may be flush with face.
 - 2. Install a second flexible joint, whether or not shown.
 - a. Pipe Diameter 18 Inches and Smaller: Within 18 inches of first joint.
 - b. Pipe Diameter Larger than 18 Inches: Within two to three pipe diameter of first joint.

3.03 PIPING TRANSITION

A. Applications:

1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipe where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:

1. Flexible Transition Couplings: Install in accordance with coupling manufacturer's instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.
2. Concrete Closures:
 - a. Locate away from structures so there are at least two flexible joints between closure and pipe entering structure.
 - b. Clean pipe surface before placing closure collars.
 - c. Wet nonmetallic pipe thoroughly prior to pouring collars.
 - d. Prevent concrete from entering pipe.
 - e. Extend collar a minimum of 12 inches on each side of joint with minimum thickness of 6 inches around outside diameter of pipe.
 - f. Make entire collar in one placement.
 - g. After concrete has reached initial set, cure by covering with well-moistened earth.

3.04 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:

1. Flanged and Welded Piping Systems: Elastomer bellows expansion joint.
2. Grooved Joint Piping Systems: A combination of elastomer bellows expansion joints and flexibility provided by the grooved joint couplings may be employed. Layout and flexibility calculations shall be provided

by the flexible coupling manufacturer based on a cold temperature of 40 degrees F and a hot temperature of 200 degrees F for the ALP piping.

- C. Anchors: Install as specified in Section 40 05 15, Piping Support Systems, to withstand expansion joint thrust loads and to direct and control thermal expansion.

3.05 SERVICE SADDLES

- A. Ferrous Metal Piping (except stainless steel): Double-strap iron.
- B. Plastic Piping: Nylon-coated iron.

3.06 OUTLET/TAPPING SADDLE

- A. Install in accordance with manufacturer's written instructions.

3.07 COUPLINGS

- A. General:
 - 1. Install in accordance with manufacturer's written instructions.
 - 2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
 - 3. Remove pipe coating if necessary to present smooth surface.
 - 4. Application:
 - a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
 - b. Concrete Encased Couplings: Flexible coupling.

3.08 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

- A. Install to prevent piping from being supported by equipment, for vibration isolation, and where shown.
- B. Product Applications Unless Shown Otherwise:
 - 1. Elastomer bellows connector.
- C. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system, particularly before system hydrostatic or pneumatic testing.

3.09 PIPE SLEEVES

A. Application:

1. As specified in Section 40 27 00, Process Piping—General.
2. Above Grade in Nonsubmerged Areas: Hot-dip galvanized after fabrication.
3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.
4. Alternatively, Molded Polyethylene Pipe Sleeve as specified may be applied.

B. Installation:

1. Support noninsulating type securely in formwork to prevent contact with reinforcing steel and tie-wires.
2. Caulk joint with specified sealant in non-submerged applications and seal below grade and submerged applications with wall penetration seal.

3.10 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Watertight and Below Ground Penetrations:
 - a. Wall pipes with thrust collars.
 - b. Provide taps for stud bolts in flanges to be set flush with wall face.
2. Nonwatertight Penetrations: Pipe sleeves with seep ring.
3. Existing Walls: Rotary drilled holes.

B. Wall Pipe Installation:

1. Isolate embedded metallic piping from concrete reinforcement.
2. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

END OF SECTION

SECTION 40 27 02
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA): 3, Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids.
2. American National Standards Institute (ANSI): Z21.15, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
3. American Society of Mechanical Engineers (ASME):
 - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
 - b. B16.44, Manually Operated Metallic Gas Valves for Use in Above Ground Piping Systems up to 5 psi.
4. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
5. American Water Works Association (AWWA):
 - a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - b. C500, Metal-Seated Gate Valves for Water Supply Service.
 - c. C504, Rubber-Seated Butterfly Valves, 3 In. (75 mm) Through 72 In. (1,800 mm).
 - d. C508, Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS.
 - e. C509, Resilient-Seated Gate Valves for Water Supply Service.
 - f. C510, Double Check Valve Backflow Prevention Assembly.
 - g. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
 - h. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
 - i. C515, Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.
 - j. C541, Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
 - k. C542, Electric Motor Actuators for Valves and Slide Gates.
 - l. C550, Protective Interior Coatings for Valves and Hydrants.
 - m. C606, Grooved and Shouldered Joints.
 - n. C800, Underground Service Line Valves and Fittings.

6. ASTM International (ASTM):
 - a. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - d. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
 - e. B61, Standard Specification for Steam or Valve Bronze Castings.
 - f. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - g. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
 - h. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
 - i. B139/B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
 - j. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
 - k. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
 - l. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
 - m. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
 - n. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
7. Canadian Standards Association, Inc. (CSA): 9.1, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
8. Chlorine Institute (CI): Pamphlet 6, Piping Systems for Dry Chlorine.
9. FM Global (FM).
10. Food and Drug Administration (FDA).
11. International Association of Plumbing and Mechanical Officials (IAPMO).
12. Manufacturers Standardization Society (MSS):
 - a. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
 - b. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.
 - c. SP-85, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.
 - d. SP-88, Diaphragm Valves.
 - e. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

13. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
14. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
15. Underwriters Laboratories (UL).
16. USC Foundation for Cross-Connection Control and Hydraulic Research.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
 - b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
 - c. Power and control wiring diagrams, including terminals and numbers.
 - d. For each power actuator provided, manufacturer's standard data sheet, with application specific features and options clearly identified.
 - e. Sizing calculations for open-close/throttle and modulating valves.
 - f. Anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for:
 - a. Electric actuators; full compliance with AWWA C542.
 - b. Butterfly valves; full compliance with AWWA C504.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
4. Tests and inspection data.
5. Operation and Maintenance Data as specified in Section 01 76 00, Operating and Maintenance Information.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

PART 2 PRODUCTS

2.01 GENERAL

- A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.
- B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.
- C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.
- D. Valve ends to suit adjacent piping.
- E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.
- F. Size operators and actuators to operate valve for full range of pressures and velocities.
- G. Valve to open by turning counterclockwise, unless otherwise specified.
- H. Factory mount operator, actuator, and accessories.
- I. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 - 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SCHEDULE

- A. Additional requirements relative to this section are shown on Electric Motor Actuated Valve Schedule and Self-Regulated Valve Schedule located at the end of this section.

2.03 MATERIALS

- A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.
 - 1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
 - 2. Stainless steel Alloy 18-8 may be substituted for bronze.
- B. Valve materials in contact with or intended for drinking water service to meet the following requirements:
 - 1. Materials to comply with requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements.
 - 2. Coatings materials to be formulated from materials deemed acceptable to NSF/ANSI 61.

2.04 FACTORY FINISHING

- A. General:
 - 1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
 - 2. Exterior coating for valves and hydrants shall be in accordance with Section 09 90 00, Painting and Coating. Coat valves the same as the pipe in which they are located.
 - 3. Material in contact with potable water shall conform to NSF/ANSI 61.
- B. Where epoxy lining and coating are specified, factory finishing shall be as follows:
 - 1. In accordance with AWWA C550.
 - 2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as "fusion" or "fusion bonded" epoxy.
 - 3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

2.05 VALVES

A. Globe Valves:

1. Type V201 Angle Pattern Valve 2 Inches and Smaller:
 - a. All-bronze, NPT threaded ends, union bonnet, packed gland, inside screw, rising stem, TFE disc, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.
 - b. Manufacturers and Products:
 - 1) Stockham; Figure B-222T.
 - 2) Crane Co.; Figure 17TF.
2. Type V208 Needle Disc Type Globe Valve 1/8 to 3/4 Inch:
 - a. All-bronze, threaded bonnet, packed gland, rising stem, bronze body and stem, Class 200 rated 200 psi SWP/400 psi CWP, complies with MSS SP-80.
 - b. Manufacturers and Products:
 - 1) Crane Cat.; No. 88.
 - 2) Stockham; B-64.
3. Type V235 Angle Type Hose Valve 3/4 Inch:
 - a. 3/4-inch NPT female inlet, 3/4-inch male hose thread outlet, heavy rough brass body rated 125 psi, lockshield bonnet, removable handle, atmospheric vacuum breaker conforming to ASSE 1011 and IAPMO code.
 - b. Manufacturers and Products:
 - 1) Acorn; 8126, surface pipe mount valve, bent nose without flange.
 - 2) Acorn; 8121, surface mount through wall valve, bent nose with flange.
 - 3) Acorn; 8131, pipe and pedestal mounted valve located above 6 inches, straightnose.
 - 4) Acorn; 8136, pedestal mounted valve located lower than 6 inches, inverted nose.
4. Type V237 Angle Pattern Hose Valve 1 Inch to 2 Inches:
 - a. All-bronze, NPT threaded ends, inside screw-type rising stem, TFE disc, cast brass male NPT by male NHT adapter with hexagonal center wrench nut, complies with MSS SP-80, rated 300 WOG.
 - b. Manufacturers and Products:
 - 1) Stockham; Figure B-222T.
 - 2) Crane Co.; Cat. No. 17TF.
 - 3) Nibco; Figure T-335-Y.

B. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
 - a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
 - b. Manufacturers and Products:
 - 1) Threaded:
 - a) Conbraco Apollo; 70-100.
 - b) Nibco; T-580-70.
 - 2) Soldered:
 - a) Conbraco Apollo; 70-200.
 - b) Nibco; S-580-70.
2. Type V306 Stainless Steel Ball Valve 2 Inches and Smaller:
 - a. Two-piece, full port, ASTM A276 GR 316 or ASTM A351/A351M GR CF8M stainless steel body and end piece, NPT threaded ends, ASTM A276 Type 316 stainless steel ball, reinforced PTFE seats, seals, and packing, adjustable packing gland, blowout proof stainless steel stem, stainless steel lever operator with vinyl grip, rated 1,000 psig CWP, complies with MSS SP-110.
 - b. Manufacturers and Products:
 - 1) Conbraco Apollo; 76F-100 Series.
 - 2) Nibco; T-585-S6-R-66-LL.

C. Plug Valves:

1. Type V405 Eccentric Plug Valve 3 to 12 Inches:
 - a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1 or grooved ends in accordance with AWWA C606 for rigid joints, buried service mechanical joint ends, unless otherwise shown.
 - b. Plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
 - c. For buried service, provide external epoxy coating.

- d. Operators:
 - 1) 3- to 4-Inch Valves: Wrench lever manual.
 - 2) 6- to 12-Inch Valves: Totally enclosed, geared, manual operator with handwheel, 2-inch nut or chain wheel. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.
- e. Manufacturers and Products:
 - 1) Pratt; Ballcentric.
 - 2) DeZurik; Style PEC.
 - 3) Milliken; Millcentric Series 600.
- 2. Type V406 Eccentric Plug Valve 14 to 20 Inches:
 - a. Nonlubricated type rated 150 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1 or grooved ends in accordance with AWWA C606 for rigid joints, buried service mechanical joints ends, unless otherwise shown, plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
 - b. Totally enclosed, geared, manual operator with handwheel, 2-inch nut or chain wheel. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.
 - c. For buried service, provide external epoxy coating.
 - d. Manufacturers and Products:
 - 1) Pratt; Ballcentric.
 - 2) DeZurik; Style PEC.
 - 3) Milliken; Millcentric Series 600.
- 3. Type V407 Eccentric Plug Valve 24 to 48 Inches:
 - a. Nonlubricated type rated 150 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1, buried service mechanical joints ends unless otherwise shown, plug cast iron port opening of no less than 70 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
 - b. Totally enclosed, geared, manual operator with handwheel, 2-inch nut, or chain wheel. Size operator for 1.5 times maximum

- operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant.
- c. For buried service, provide external epoxy coating.
 - d. Manufacturers and Products:
 - 1) Pratt; Ballcentric.
 - 2) DeZurik; Style PEC.
 - 3) Milliken; Millcentric Series 600.
4. Type V410 Three-Way, Nonlubricated, Tapered Plug Valve 3 to 16 Inches:
- a. Cast-iron body with Buna-N-coated plug, multiple V-rings or U-cups with O-ring seals, lubricated stainless steel bearings, and nickel- or epoxy-coated seat, rated 125 psi CWP minimum, flanged to ASME B16.1.
 - b. Operator: Lever type, 4-inch and smaller, gear type, totally enclosed and lubricated, with handwheel, 6-inch and larger. For buried valves, in lieu of lever or handwheel, provide 2-inch square operating nut.
 - c. Manufacturers and Products:
 - 1) DeZurik; Style PTW, Combination 3.
 - 2) Milliken; Millcentric Series 600, Style F.
5. Type V411Curb Valve Stop and Drain, 3/4 to 2 Inches:
- a. AWWA C800 type, IPS female threaded inlet and outlet. Drain port to drain downstream line when valve is closed.
 - b. Manufacturers and Products
 - 1) Mueller Co.; H10284
 - 2) Ford Meter Box Co.
6. Type V464 Corporation Ball Stop 1/2 to 2 Inches:
- a. AWWA C800 type ball style corporation stop, tapered threaded inlet, except when connecting to tapped fittings which require IPS tapered threads, outlet compression connection or IPS threads to suit connecting pipe, rated 150 psi.
 - b. Manufacturers and Product:
 - 1) Ford Meter Box Co.; Ballcorp.
 - 2) Mueller Co.
 - 3) Or equal.

D. Butterfly Valves:

1. General:
 - a. In full compliance with AWWA C504 and following requirements:
 - 1) Suitable for throttling operations and infrequent operation after periods of inactivity.

- 2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.
 - 3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
 - 4) No travel stops for disc on interior of body.
 - 5) Self-adjusting V-type or O-ring shaft seals.
 - 6) Isolate metal-to-metal thrust bearing surfaces from flowstream.
 - 7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
 - 8) Buried service operators shall withstand 450 foot-pounds of input torque at fully open and fully closed positions.
 - 9) Provide linings and coatings per AWWA, unless otherwise indicated on Drawings or specified herein.
 - b. Non-AWWA butterfly valves to meet the following actuator requirements:
 - 1) For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on Drawings or specified herein.
2. Type V500 Butterfly Valve Water Works Service 3 Inches to 72 Inches:
 - a. AWWA C504, Class 150B.
 - b. Short body type, flanged ends.
 - c. Cast-iron body, cast or ductile iron disc, Type 304 stainless steel shafts, Buna-N rubber seat, and stainless steel seating surface.
 - d. Provide epoxy lining and coating in compliance with AWWA C550.
 - e. Manufacturers and Products:
 - 1) Pratt; Model 2FII or Triton XR-70.
 - 2) DeZurik; AWWA Valve.
 3. Type V510 Lug Style Butterfly Valve, Resilient Seated, 2 to 20 Inches for Low Pressure Process Air Service:
 - a. Lug style cast-iron body, aluminum bronze discs, Type 316 stainless steel one-piece stem, self-lubricating sleeve type bushings, EPDM replaceable resilient seat suitable for operating temperatures up to 250 degrees F, 150 psi working pressure rating, bubble-tight at 50 psi differential pressure, valve body to fit between ASME B16.1 Class 125/150 flanges.

- b. Manufacturers and Products:
 - 1) Bray Controls; Series 31.
 - 2) Tyco/Keystone; Model AR2.
 - 3) Centerline; Series 225.
 - 4. Type V513 Butterfly Valve 2 Inches to 20 Inches:
 - a. Lug style, cast-iron or ductile iron body, aluminum bronze disc, Type 316 or Type 18-8 stainless steel one-piece stem, Buna-N replaceable resilient seat, heavy-duty self-lubricating sleeve type bushings, NBR stem seal, 150 psi working pressure rating, valve body to fit between ASME B16.1 Class 125/150 flanges.
 - b. Manufacturers and Products:
 - 1) Bray Controls; Series 30/31.
 - 2) Tyco/Keystone; Model AR1/AR2.
 - 3) Crane/Centerline; Series 200.
- E. Check and Flap Valves:
- 1. Type V608 Swing Check Valve 2 to 30 Inches:
 - a. AWWA C508, 125-pound flanged ends, cast-iron body, bronze body seat, bronze mounted cast-iron clapper with bronze seat, stainless steel hinge shaft.
 - b. Valves, 2 through 12 inches rated 175-pound WWP and 14 through 30 inches rated 150-pound WWP. Valves to be fitted with adjustable outside lever and weight. Increasing-pattern body valve may be used where increased outlet piping size is shown.
 - c. Manufacturers and Products:
 - 1) M&H Valve; Style 159.
 - 2) Mueller Co.; No. A-2600 or 8001Series.
 - 2. Type V694 Check Valve 1 to 48 Inches:
 - a. Elastomer type flanged or slip-on as shown on Drawings, round entry area to match pipe, contoured duckbilled shaped exit, flat bottom and off-set bill design, curved bill for 18 inches and larger, valve open with approximately 2 inches of line pressure and return to CLOSED position under zero flow condition, rated for 50 psi minimum operating pressure; flanges steel backing flange type, drilled to ASME B16.1, Class 125, plain-end valve attached with two Type 316 stainless steel adjustable bands, elastomer nylon-reinforced neoprene.
 - b. Manufacturer and Product: Red Valve Co.; Tideflex Check Valve Series TF-1 or 35-1.

F. Self-Regulated Automatic Valves:

1. Type V710 Pressure-Reducing Valve 2-1/2 Inches and Smaller:
 - a. Direct diaphragm operated, spring controlled, bronze body, NPT threaded ends, 200-psig rated minimum.
 - b. Size/Rating: As shown in Valve Schedule.
 - c. Manufacturers and Products:
 - 1) Fisher; Type 75A.
 - 2) Watts; Series 223.
2. Type V750 Sewage Air and Vacuum Valve 2 to 14 Inches:
 - a. Suitable for sewage service; automatically exhausts air during system filling and allows air to re-enter during draining or when vacuum occurs.
 - b. Rated working pressure of 150 psi, 1- through 3-inch valves with NPT threaded inlet and outlet, 4-inch and larger valves with ASME B16.1 Class 125 flanged inlet and threaded cover outlet, built and tested to AWWA C512.
 - c. Materials: Cast-iron or ductile iron body and cover, concave or skirted stainless steel float and trim, Buna-N seat.
 - d. Sewage air and vacuum valve fitted with blowoff valve, flushing valve with quick disconnect couplings, and a minimum 5 feet of hose with quick disconnect couplings to permit backflushing after installation without dismantling valve.
 - e. Manufacturers and Products:
 - 1) APCO Valve and Primer Corp.; Series 401 SAVV to 414 SAVV.
 - 2) Val-Matic Valve; Series 301 to 306.
3. Type V752 Sewage Air Release Valve 2 to 4 Inches:
 - a. Suitable for sewage service; automatically exhausts entrained air that accumulates in a system.
 - b. Rated working pressure of 150 psi, operating pressure of 20 psi, built and tested to AWWA C512.
 - c. Materials: Cast-iron or ductile iron body and cover with NPT threaded inlet and 1/2-inch NPT threaded outlet, concave or skirted stainless steel float and trim; Buna-N resilient seat.
 - d. Sewage air release valve fitted with blowoff valve, flushing valve with quick disconnect couplings, and a minimum 5 feet of hose with quick disconnect couplings to permit backflushing after installation without dismantling valve.
 - e. Manufacturers and Products:
 - 1) APCO Valve and Primer Corp.; Series 400 SARV or 450 SARV.
 - 2) Val-Matic Valve; Series 48 or 49.

4. Type V754 Sewage Combination Air Valve 2 to 6 Inches:
 - a. Suitable for sewage service; combines operating functions of air and vacuum valve and an air release valve. Air and vacuum portion shall automatically exhaust air during filling of a system and allow air to re-enter during draining or when a vacuum occurs. Air release portion to automatically exhaust entrained air that accumulates in system. Single body unit with air and vacuum valve and an air release valve in a single housing.
 - b. Rated working pressure of 150 psi; built and tested to AWWA C512.
 - c. Materials: Cast-iron or ductile iron body and covers, NTP threaded inlet and outlet, with concave or skirted stainless steel float and trim.
 - d. Sewage air release valve fitted with blowoff valve, flushing valve with quick disconnect couplings, and a minimum 5 feet of hose with quick disconnect couplings to permit backflushing after installation without dismantling valve.
 - e. Manufacturers and Products:
 - 1) APCO Valve and Primer Corp.; Series 440 SCAV.
 - 2) Val-Matic Valve; Series 800.

G. Miscellaneous Valves:

1. Type V921 Hydrostatic Pressure Relief Valve, Wall Type 6 Inches:
 - a. Wall type, flange style frame, cast-iron body and cover, bronze seat body, resilient rubber seat on cover, bronze hinge pins, cast-iron wall pipe with integral seep ring and strainer, length as shown on Drawings.
 - b. Manufacturers and Products:
 - 1) M&H Valve; Style 147, F-1494/F-1496.
 - 2) Clow Valve; Figure F-1494/F-1496.
2. Type V935 Non-Freeze Post Hydrant:
 - a. Non-freeze bronze casing, suitable for minimum 3-foot deep inlet pipe.
 - b. Size as noted on Drawings.
 - c. All working pieces to be removable through the top of the hydrant.
 - d. Manufacturer and Product:
 - 1) Iowa Woodford; Model U Utility Hydrant Series.
 - 2) Or equal.

2.06 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:
 - a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.
 - b. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
 - c. Operator self-locking type or equipped with self-locking device.
 - d. Position indicator on quarter-turn valves.
 - e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
 - a. Galvanized and painted handwheel.
 - b. Cranks on gear type operator.
 - c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
 - d. Valve handles to take a padlock, and wheels a chain and padlock.
3. Buried Operator:
 - a. Buried service operators on valves larger than 2-1/2 inches shall have a 2-inch AWWA operating nut. Buried operators on valves 2 inches and smaller shall have cross handle for operation by forked key. Enclose moving parts of valve and operator in housing to prevent contact with the soil.
 - b. Buried service operators to be grease packed and gasketed to withstand submersion in water to 20 feet minimum.
 - c. Buried valves shall have extension stems, bonnets, and valve boxes.

B. Electric Operators, 120 Volts:

1. General:
 - a. Unit shall be low profile to reduce amount of required space and weigh 15 pounds or less.
 - b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of the valve.
 - c. Provide operator mounting bracket to mount operator to valve providing minimal torque to piping system when operating.

2. Operator Operation, General:
 - a. Suitable for full 90-degree rotation of quarter-turn valves.
 - b. Manually override handwheel.
 - c. Mechanical valve position indication.
3. Electronic Control:
 - a. Torque Limiting Switches: Two single pole, double throw mechanical switches. Switches operate at any point in valve travel.
 - b. Jammed-valve detection and protection.
 - c. Motor over-temperature detection and protection.
 - d. Travel limit switches, single pole double throw.
4. Open-Close (O/C) Service:
 - a. Duty cycle for intermittent ON-OFF operation shall be 25 percent.
 - b. Operator shall power to OPEN and power to CLOSE.
 - c. Local Indication and Control:
 - 1) Integral mechanical valve POSITION indication, 0 percent to 100 percent OPENED.
 - 2) Integral OPENED and CLOSED indication lights.
 - 3) Integral LOCAL-OFF-REMOTE (L-O-R).
 - 4) Integral OPEN maintained switch which causes the valve to stroke full OPENED, even if OPEN switch is released, while L-O-R switch is in LOCAL.
 - 5) Integral CLOSE maintained switch which causes valve to stroke full CLOSED, even if CLOSED switch is released, while L-O-R switch is in LOCAL.
 - d. Remote Indication and Control:
 - 1) Relay contact that closes when valve is capable of being controlled remotely (L-O-R switch in REMOTE) for connection to and monitoring by plant control system.
 - 2) Limit switch that closes when valve is fully OPENED for connection to and monitoring by plant control system.
 - 3) Limit switch that closes when valve is fully CLOSED for connection to and monitoring by plant control system.
 - e. Modulating (M) Service:
 - 1) Operator rated for continuous duty with servo shall be rated for 100 percent modulating operation.
 - 2) Operator shall modulate based on an externally applied 4 mA to 20 mA dc signal.
 - 3) Operator shall be equipped with an electronic servo module for valve modulation.
 - a) Module shall provide serial communications with provided cable for setup of valve operation.
 - f. Local Indication and Control:
 - 1) Integral mechanical valve POSITION indication, 0 percent to 100 percent OPENED.

- 2) Integral OPENED and CLOSED indication lights.
 - 3) Integral LOCAL-OFF-REMOTE (L-O-R).
 - 4) Integral OPEN momentary switch which causes valve to stroke towards OPENED, as long as OPEN switch is held, while L-O-R switch is in LOCAL.
 - 5) Integral CLOSE momentary switch which causes valve to stroke towards CLOSED, as long as CLOSED switch is held, while L-O-R switch is in LOCAL.
 - 6) Position valve proportionally 0 to 100 percent OPEN with external 4 mA to 20 mA dc signal while in REMOTE.
 - g. Remote Indication and Control:
 - 1) Relay contact that closes when valve is capable of being controlled remotely (L-O-R switch in REMOTE) for connection to and monitoring by plant control system.
 - 2) Limit switch that closes when valve is fully OPENED for connection to and monitoring by plant control system.
 - 3) Limit switch that closes when valve is fully CLOSED for connection to and monitoring by plant control system.
 - 4) Current Position Transmitter, 4 mA to 20 mA dc signal in proportion to 0 percent to 100 percent OPENED, with 0.5 percent accuracy and 0.5 percent repeatability, capable of driving a 750-ohm load, for connection to and monitoring by Plant Control System.
 5. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.
 6. Manufacturer and Product:
 - a. Rotork; RomPak.
 - b. Or equal.
- C. Electric Motor Actuators, 480 Volts:
1. General:
 - a. Comply with latest version of AWWA C542. Actuators may be sized to operate valves at 1.5 times the maximum differential pressure listed in the Electric Actuated Valve Schedule and are not required to operate valve at the rated working pressure of the valve.
 - b. Size to 1-1/2 times required operating torque at 1.5 times the listed maximum differential pressure. Motor stall torque not to exceed torque capacity of valve.
 - c. Controls integral with actuator and fully equipped as specified in AWWA C542.

- d. Provide gear box and multi-turn actuators for quarter-turn valves whose torque requirements exceed those of the quarter-turn models of the valve actuators listed.
- e. Stem protection for rising stem valves.
2. Actuator Operation—General:
 - a. Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves, as applicable.
 - b. Manual override handwheel.
 - c. Valve position indication.
 - d. Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in Electric Actuated Valve Schedule.
 - e. Nonintrusive Electronic Control: Local controls, diagnostics, and calibration, including limit and torque settings, shall be accomplished nonintrusively. Electronic valve position display with capability to show continuous torque output. If applicable, provide two hand-held configuration units for every 10 actuators provided, two minimum.
3. Open-Close(O/C)/Throttling(T) Service:
 - a. Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes.
 - b. Actuator suitable for throttling operation of valve at intermediate positions.
 - c. LOCAL-OFF-REMOTE Selector Switch, padlockable in each position:
 - 1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
 - 2) Remote OPEN-STOP-CLOSE momentary control dry contact inputs in REMOTE position. Integral seal-in circuits for remote OPEN and CLOSE commands; valve travel stops when remote STOP contact opens.
 - 3) Auxiliary contact that closes in REMOTE position.
 - d. OPEN and CLOSED indicating lights.
 - e. Integral reversing motor starter with built-in overload protection.
4. Modulating (M) Service:
 - a. Size actuators for continuous modulating duty.
 - b. Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain valve position.
 - c. HAND-OFF-AUTO (Local-Off-Remote) Selector Switch, padlockable in each position:
 - 1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in HAND (Local) position.
 - 2) 4 mA to 20 mA dc input signal to control valve in AUTO (Remote) position.
 - 3) Auxiliary contact that closes in AUTO (Remote) position.

- d. OPEN and CLOSED indicating lights.
 - e. Ac motor with solid state reversing starter or dc motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour.
 - f. Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.
 - g. Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.
5. Limit Switch:
- a. Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.
 - b. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
 - c. Housed in actuator control enclosure.
6. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.
7. Manufacturers and Products:
- a. Rotork Controls; IQ Range.
 - b. Flowserve Limitorque; MX.
 - c. AUMA; SA/SAR with Aumatic Controls.

2.07 ACCESSORIES

- A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each valve with a P&ID tag number bearing valve tag number shown on Electric Actuated Valve Schedule and Self-Regulated Valve Schedule.
- B. Limit Switch:
1. Factory installed NEMA 4X limit switch by actuator manufacturer.
 2. SPST, rated at 5 amps, 120 volts ac.
- C. Cast-Iron Valve Box: Designed for traffic loads, sliding type, with minimum of 5-1/4-inch ID shaft.
1. Box: Cast iron with minimum depth of 9 inches.
 2. Lid: Cast iron, minimum depth 3 inches, nonlocking type, marked WATER or SEWER based on service.
 3. Extensions: Cast iron.
 4. Two-piece box and lid for valves 4 through 12 inches, three-piece box and lid for valves larger than 12 inches with base sized for valve.
 5. Valve extension stem for valves with operating nuts 3 feet or greater below finish grade.

6. Manufacturers and Products:
 - a. East Jordan Iron Works; Cast-Iron Valve Boxes.
 - b. Bingham & Taylor; Cast-Iron Valve Boxes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. Valve Installation and Orientation:

1. General:

- a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
- b. Install valves in location for easy access for routine operation and maintenance.
- c. Install valves per manufacturer's recommendations.

2. Gate, Globe, and Ball Valves:

- a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
- b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.

3. Eccentric Plug Valves: Unless otherwise restricted or shown on Drawings, install valve as follows:

- a. Liquids with suspended solids service with horizontal flow: Install valve with stem in horizontal position with plug up when valve is open. Install valve with seat end upstream (flow to produce unseating pressure).
- b. Liquids with suspended solids service with vertical flow: Install valve with seat in highest portion of valve (seat up).
- c. Clean Liquids and Gas Service: Install valve with seat end downstream of higher pressure when valve is closed (higher pressure forces plug into seat).

4. Butterfly Valves:
 - a. Unless otherwise restricted or shown on Drawings, install valve a minimum of 8 diameters downstream of a horizontal elbow or branch tee with shaft in horizontal position.
 - b. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
 - c. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
 - d. When installed immediately downstream of swing check, install valve with shaft perpendicular to swing check shaft.
 - e. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.
 5. Check Valves:
 - a. Install valve in accordance with manufacturer's instructions and provide required distance from immediate upstream fitting.
 - b. Install valve in vertical flow (up) piping only for gas services.
 - c. Install swing check valve with shaft in horizontal position.
 - d. Install double disc swing check valve to be perpendicular to flow pattern when discs are open.
- D. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.
- E. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.
- F. Extension Stem for Operator: Where depth of valve operating nut is 3 feet or greater below finish grade, furnish operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.

3.02 TESTS AND INSPECTION

- A. Valve may be either tested while testing pipelines, or as a separate step.
- B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.
- C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.
- D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer's data.
- E. Set, verify, and record set pressures for relief and regulating valves.

- F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.
- G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative for Actuated Valves: Present at Site for minimum person-days listed below, travel time excluded:
 - 1. 4 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation; 1 day for PEPS and 1 day for each of the three aeration basins.
- B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 75 00, Testing, Equipment Startup, and Commissioning.

3.04 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are part of this Specification.
 - 1. Electric Actuated Valve Schedule.
 - 2. Self-Regulated Valve Schedule.

END OF SECTION

Electric Actuated Valve Schedule									
Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Process Fluid	Maximum Operating Flow (gpm)	Maximum ΔP (psi)	Service	Travel Time (Seconds)	Control Feature Modifications/ Supplements
3104-FVPEP1	V500	480/3	30	SI	10000	25	OC	30	
3105-FVPEP2	V500	480/3	30	SI	10000	25	OC	30	
3106-FVPEP3	V500	480/3	30	SI	10000	25	OC	30	
3411-ABFCV1	V500	480/3	24	SI	7000	20	M	30	C, J
3412-ABFCV2	V500	480/3	24	SI	7000	20	M	30	C, J
3413-ABFCV3	V500	480/3	24	SI	7000	20	M	30	C, J
4475-RASFV1	V406	480/3	18	RAS	6000	20	OC	30	
4476-RASFV2	V406	480/3	18	RAS	6000	20	OC	30	
4477-RASFV3	V4076	480/3	18	RAS	6000	20	OC	30	
4439-RASCV1	V406	480/3	18	RAS	6000	20	M	30	C, J
4440-RASCV2	V406	480/3	18	RAS	6000	20	M	30	C, J
4441-RASCV3	V406	480/3	18	RAS	6000	20	M	30	C, J
4463-SZFCV1	V500	480/3	16	SI	7000	20	M	30	C, J
4466-SZFCV2	V500	480/3	16	SI	7000	20	M	30	C, J
4470-SZFCV3	V500	480/3	16	SI	7000	20	M	30	C, J
4464-FZFCV1	V500	480/3	16	SI	5500	20	M	30	C, J
4465-FZFCV2	V500	480/3	16	SI	5500	20	M	30	C, J
4469-FZFCV3	V500	480/3	16	SI	5500	20	M	30	C, J
4421-AB1CV1	V510	480/3	8	ALP		12	M	20	C, J

Electric Actuated Valve Schedule									
Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Process Fluid	Maximum Operating Flow (gpm)	Maximum ΔP (psi)	Service	Travel Time (Seconds)	Control Feature Modifications/Supplements
4422-AB1CV2	V510	480/3	8	ALP		12	M	20	C, J
4423-AB1CV3	V510	480/3	4	ALP		12	M	20	C, J
4424-AB1CV4	V510	480/3	4	ALP		12	M	20	C, J
4425-AB1CV5	V510	480/3	4	ALP		12	M	20	C, J
4426-AB2CV1	V510	480/3	8	ALP		12	M	20	C, J
4427-AB2CV2	V510	480/3	8	ALP		12	M	20	C, J
4428-AB2CV3	V510	480/3	4	ALP		12	M	20	C, J
4429-AB2CV4	V510	480/3	4	ALP		12	M	20	C, J
4430-AB2CV5	V510	480/3	4	ALP		12	M	20	C, J
4431-AB3CV1	V510	480/3	8	ALP		12	M	20	C, J
4432-AB2CV2	V510	480/3	8	ALP		12	M	20	C, J
4433-AB2CV3	V510	480/3	4	ALP		12	M	20	C, J
4434-AB3CV4	V510	480/3	4	ALP		12	M	20	C, J
4435-AB3CV5	V510	480/3	4	ALP		12	M	20	C, J

Electric Actuated Valve Schedule									
Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Process Fluid	Maximum Operating Flow (gpm)	Maximum ΔP (psi)	Service	Travel Time (Seconds)	Control Feature Modifications/Supplements
Service: O/C = Open-Close, T = Throttling, M = Modulating Control Feature Modifications/Supplements: A = Actuator shall open valve upon loss of signal. B = Actuator shall close valve upon loss of signal. C = Actuator shall remain in last position upon loss of signal. D = Local OPEN-CLOSE momentary pushbuttons that must be continuously depressed to initiate/maintain valve travel; travel stops when pushbutton is released or when end of travel limit is reached. E = Remote OPEN-CLOSE maintained dry contacts; travel stops when remote contact opens, or when end of travel limit is reached. F = Three 24-volt dc interposing relays for remote OPEN-STOP-CLOSE control. Relays powered externally, thereby permitting valve control from greater distances. G = Motor and control enclosure(s) NEMA 250, Type 4 with 120-volt space heaters. H = Motor and control enclosure(s) NEMA 250, Type 6 (IP 68) with 120-volt space heaters. I = Motor and control enclosure(s) NEMA 250, Type 7 with 120-volt space heaters. J = Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc. K = 120-volt secondary control power transformer. L = Externally operable power disconnect switch.									

Self-Regulated Valve Schedule							
Tag No.	Valve Type No.	Size (inches)	Inlet Pressure	Outlet Pressure	Maximum Inlet psig	Flow (gpm)	Fluid
3078 PRV	V710	1/2	70	20 - 40	100	1 - 3	No. 4

SECTION 40 42 13
PROCESS PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
 2. ASTM International (ASTM):
 - a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - b. C165, Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
 - c. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
 - d. C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
 - e. C534/C534M, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
 - f. C547, Standard Specification for Mineral Fiber Pipe Insulation.
 - g. C552, Standard Specification for Cellular Glass Thermal Insulation.
 - h. C585, Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
 - i. C1136, Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
 - j. C1729, Standard Specification for Aluminum Jacketing for Insulation.
 - k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 - l. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
 3. International Code Council (ICC): International Energy Conservation Code (IECC).
 4. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

- A. Action Submittals: Manufacturer's descriptive literature.
- B. Informational Submittals: Maintenance information.

PART 2 PRODUCTS

2.01 PIPE AND FITTING INSULATION

- A. Type 1—Elastomeric:
 - 1. Material: Flexible elastomeric pipe insulation, closed-cell structure in accordance with ASTM C534/C534M.
 - 2. Temperature Rating: Minus 297 degrees F to 220 degrees F.
 - 3. Nominal Density: 3 pcf to 6 pcf.
 - 4. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.25 Btu-in./hr-square foot degrees F at 75 degrees F per ASTM C177 or ASTM C518.
 - 5. Maximum water vapor transmission of 0.06 perm-inch per ASTM E96/E96M, Procedure A.
 - 6. Joints: Manufacturer's adhesive.
 - 7. Flame Spread Rating: Less than 25 per ASTM E84.
 - 8. Smoke Developed Index: Less than 50 per ASTM E84.
 - 9. Manufacturers and Products:
 - a. Nomaco; K-Flex.
 - b. Armacell; AP Armaflex.
- B. Type 2—Fiberglass:
 - 1. Material: UL rated, preformed, sectional bonded fiberglass per ASTM C585 with factory applied, Kraft paper with aluminum foil vapor barrier jacket with pressure-sensitive, self-sealing lap.
 - 2. Insulation Temperature Rating: Zero to 850 degrees F.
 - 3. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.23 Btu-in./hr-square foot degrees F at 75 degrees F.
 - 4. Jacketing per ASTM C1136 with minimum water vapor transmission for jacket of 0.02 perm-inch per ASTM E96/E96M. Furnish with no jacket if field finish system specified.
 - 5. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
 - 6. Flame Spread Rating: Less than 25 per ASTM E84.
 - 7. Smoke Developed Index: Less than 50 per ASTM E84.

8. Manufacturers and Products:
 - a. Owens Corning Fiberglass; ASJ/SSL-11.
 - b. John Manville; Micro-Lok with Jacket.

C. Type 3—Foamglass:

1. Material: Cellular glass per ASTM C552.
2. Nominal Density: 7.5 pcf.
3. Compressive Strength: 90 psi per ASTM C165.
4. Temperature Rating: Minus 290 degrees F to 900 degrees F.
5. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.29 Btu-in./hr-square foot degrees F.
6. Minimum water vapor transmission for insulation of 0.00 perm-inch per ASTM E96/E96M.
7. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
8. Flame Spread Rating: 0 per ASTM E84.
9. Smoke Developed Index: 0 per ASTM E84.
10. Follow manufacturer's recommendation, based upon temperature of piping to be insulated.
11. Manufacturer and Product: Pittsburgh Corning; Foamglas One.

2.02 ROOF DRAIN AND OVERFLOW DRAIN SUMP INSULATION

- A. Type 1: 1 inch thick.

2.03 INSULATION AT PIPE HANGERS AND SUPPORTS

- A. Refer to Section 40 05 15, Piping Support Systems.
- B. Copper, Ductile Iron, and Nonmetallic Pipe: High-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield. Extend insert beyond shield.
- C. Steel Pipe: Insulation saddle or high-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield at support location. Extend insert beyond shield.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, minimum 20 mils indoors and 30 mils outdoors, for straight run piping and fitting locations, temperatures to 140 degrees F.
2. Color: PVC jacketing shall be color coded to match colors listed in pipe schedule where suitable matching colors are available. If no suitable colors are available jacketing shall be white.
3. Flame Spread Rating: 25 per ASTM E84.
4. Smoke Developed Index: 50 per ASTM E84.
5. Manufacturers and Products:
 - a. Knauf Insulation; Proto 1000.
 - b. Johns Manville; Zeston 2000 or 300.
 - c. Speedline; 25/50 Smoke-Safe.

B. Type F2—Paint:

1. Type 1 Insulation: Acrylic latex paint, white, and suitable for outdoor use.
 - a. Manufacturer and Product: Armacell; WB Armaflex finish.
2. Type 2 Insulation: In accordance with Section 09 90 00, Painting and Coating.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, in accordance with ASTM C1729, minimum 0.016-inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, heat and pressure bonded to inner surface of aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers:
 - a. RPR Products; Insul-Mate.
 - b. ITW, Pabco-Childers.

D. Type F4—Foamglass Jacketing:

1. Type 3 Insulation—Buried and Up to 1 Foot Above Grade: 70-mil bituminous resin with woven, glass fabric, aluminum foil layer, and plastic film coating, self-sealing manual pressure seals; Pittsburgh Corning Pittwrap SS.

2. Type 3 Insulation—Greater than 1 Foot Above Grade: 30-mil modified bituminous membrane with self-sealing manual pressure seals; Pittsburgh Corning Pittwrap CW30.

PART 3 EXECUTION

3.01 APPLICATION

A. General:

1. Insulate valve bodies, flanges, and pipe couplings.
2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
3. Do not insulate flexible pipe couplings and expansion joints.
4. Service and Insulation Thickness: Refer to Supplement Service and Insulation Thickness table following “End of Section” and to Piping Schedule in Section 40 27 00, Process Piping—General.

3.02 INSTALLATION

A. General:

1. Install in accordance with manufacturer’s instructions and as specified herein.
2. Install after piping system has been pressure tested and leaks corrected.
3. Install over clean dry surfaces.
4. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.
5. Do not allow insulation to cover nameplates or code inspection stamps.
6. Run insulation or insulation inserts continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
7. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
8. Personnel Protection: Install on pipes from floor to 8 feet high. Install on pipes within 4 feet of platforms and to 8 feet high above platforms.

B. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

C. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

- D. Placement:
 - 1. Insulate valves and fittings with sleeved or cut pieces of same material.
 - 2. Seal and tape joints.
- E. Heat Traced Piping: Apply insulation after heat-tracing work is completed and inspected.
- F. Roof Drains and Overflow Drains: Insulate entire pipe runs. Where roof and overflow drains exist through an exterior wall ensure annular space between pipes and walls are properly sealed prior to insulating.
- G. Roof Drain and Overflow Drain Sumps: Insulate entire sumps.
- H. Vapor Barrier:
 - 1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
 - 2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
 - 3. Do not use staples and screws to secure vapor sealed system components.
- I. Aluminum Jacket:
 - 1. Use continuous friction type joint to hold jacket in place, providing positive weatherproof seal over entire length of jacket.
 - 2. Secure circumferential joints with preformed snap straps containing weatherproof sealant.
 - 3. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.
 - 4. Do not use screws or rivets to fasten fitting covers.
 - 5. Install removable prefabricated aluminum covers on exterior flanges and unions.
 - 6. Caulk and seal exterior joints to make watertight.

3.03 FIELD FINISHING

- A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.
- B. Where pipe labels or banding are specified, apply to finished insulation, not to pipe.

C. Painting Piping Insulation (Exposed to View):

1. Aluminum or color coded PVC jacketing does not require painting.
2. If insulated piping system is indicated to be painted in Section 40 27 00, Process Piping—General, piping shall receive the following:
 - a. Prime coat in accordance with Section 09 90 00, Painting and Coating.
 - b. Finished insulation (and not pipe) shall be painted in accordance with Section 09 90 00, Painting and Coating.

3.04 SUPPLEMENTS

- A. The supplement listed below, following “End of Section,” is a part of this specification:
1. Service and Insulation Thickness Table.

END OF SECTION

Service and Insulation Thickness								
Service Type	Pipe Legend	Thickness	Fluid Temperature (degrees F)*	Insulation	Finish Systems			
					Concealed from View	Indoors Exposed	Outdoors	Buried
HT-Piping requiring heat tracing.	RAS SI No. 4	Pipe Size: Insulation Thickness Inches:* 1/4-3: 1 3.5-10: 1.5 12-16: 2 18-30: 2.5	60	Type 2 Insulate and heat trace outside lines 1' above grade. Use Type 3 insulation from 1' above grade to frost depth.	None	Not Applicable	F3	F4 on Type 3
<p>*Use these fluid temperatures unless otherwise noted in the Piping Schedule. Inches*: Based upon insulation with glass fiber per ASTM C547, outdoors with 20 mph wind with 10 percent safety and no value assigned to cladding or air space at cladding. Matches the watts per foot in Section 40 05 33, Pipe Heat Tracing. 2012 IECC requires 1-inch minimum thickness.</p>								

SECTION 40 80 01
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan: Submit prior to testing and include at least the information that follows.
 - a. Testing dates.
 - b. Piping systems and section(s) to be tested.
 - c. Test type.
 - d. Method of isolation.
 - e. Calculation of maximum allowable leakage for piping section(s) to be tested.
2. Certifications of Calibration: Testing equipment.
3. Certified Test Report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

- A. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.
- B. Pressure Piping:
 1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
 2. Wait 5 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
 3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
 4. New Piping Connected to Existing Piping: Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.
 5. Items that do not require testing include equipment seal drains and sump vents.
 6. Test Pressure: As indicated on Piping Schedule.

- C. Test section may be filled with water and allowed to stand under low pressure prior to testing.
- D. Gravity Piping:
 - 1. Perform testing after service connections, manholes, and backfilling have been completed between stations to be tested.
 - 2. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.
 - 3. Pipe 42 Inches Diameter and Larger: Joint testing device may be used to isolate and test individual joints.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

- A. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.
- B. Exposed Piping:
 - 1. Perform testing on installed piping prior to application of insulation.
 - 2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
 - 3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
 - 4. Maintain hydrostatic test pressure continuously for 30 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
 - 5. Examine joints and connections for leakage.
 - 6. Correct visible leakage and retest as specified.
 - 7. Leave pipe full of water after repair of leaks.
- C. Buried Piping:
 - 1. Test after backfilling has been completed.
 - 2. Expel air from piping system during filling.
 - 3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
 - 4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
 - 5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.

6. Maximum Allowable Leakage:

$$L = \frac{SD(P)^{1/2}}{133,200}$$

where:

- L = Allowable leakage, in gallons per hour.
 S = Length of pipe tested, in feet.
 D = Nominal diameter of pipe, in inches.
 P = Test pressure during leakage test, in pounds per square inch.

7. Correct leakage greater than allowable, and retest as specified.

3.03 PNEUMATIC TEST FOR PRESSURE PIPING

A. Do not perform on:

1. PVC or CPVC pipe.
2. Piping larger than 20 inches.
3. Buried and other non-exposed piping.

B. Fluid: Oil-free, dry air.

C. Procedure:

1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections; examine for leakage.
2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
3. Gradually increase pressure in system to half of specified test pressure. Thereafter, increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.
4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
5. Correct visible leakage and retest as specified.

D. Allowable Leakage: Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.

E. After testing and final cleaning, purge with nitrogen those lines that will carry flammable gases to assure no explosive mixtures will be present in system during filling process.

3.04 HYDROSTATIC TEST FOR GRAVITY PIPING

- A. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.
- B. Maximum Allowable Leakage: 0.16 gallons per hour per inch diameter per 100 feet. Include service connection footage in test section, subjected to minimum head specified.
- C. Gravity Roof Drain Piping: Test with 15 feet of water to include highest horizontal vent in filled piping. Where vertical drain and vent systems exceed 15 feet in height, test systems in 15-foot vertical sections as piping is installed.
- D. Exfiltration Test:
 - 1. Hydrostatic Head:
 - a. At least 6 feet above maximum estimated groundwater level in section being tested.
 - b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.
 - 2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.
- E. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.
- F. Defective Piping Sections: Replace or test and seal individual joints, and retest as specified.

3.05 FIELD QUALITY CONTROL

- A. Test Report Documentation:
 - 1. Test date.
 - 2. Description and identification of piping tested.
 - 3. Test fluid.
 - 4. Test pressure.
 - 5. Remarks, including:
 - a. Leaks (type, location).
 - b. Repair/replacement performed to remedy excessive leakage.
 - 6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

**SECTION 40 90 00
INSTRUMENTATION AND CONTROL
FOR PROCESS SYSTEMS**

PART 1 GENERAL

1.01 SUMMARY

- A. This section gives general requirements for Process Instrumentation and Control (PIC). The following PIC subsections expand on requirements of this section:
1. Section 40 91 00, Instrumentation and Control Components.
- B. Major Work Items: Includes but is not limited to engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and training for complete PIC.
1. Process instrumentation including primary elements, transmitters, control devices, and control panels.
 2. Programmable controllers.
 3. PLC Software:
 - a. SCADA software.
 - b. Controller programming software.
 4. HMI Software:
 - a. SCADA software.
 - b. System software.
 5. Computers and networks for Human Machine Interface (HMI).
 6. Local control panels.
 7. Complete and thorough testing of all control loop circuits, including testing of I/O wiring to the control panels. I/O to the panels includes PIC system instruments, existing panels, package system panel interfaces, interfaces to devices supplied by others, including but not limited to, motor control centers, drives, valve actuators, gate actuators, instruments and other similar devices.
 8. Coordination with Contractor, System Integrator, and Engineer on the milestones and sequences.
 9. Applications Software: Provided by System Integrator for PLCs and HMI. Work related to supporting this activity includes:
 - a. Early delivery of programming equipment to Owner.
 - b. Setup and demonstration testing of programming equipment at System Integrator's office.
 - c. Delivery of PLCs, and HMI, equipment to staging site provided by Contractor.
 - d. Assistance with onsite checkout of applications software.

- e. For additional related requirements refer to:
 - 1) Article Sequencing and Scheduling in this section.
 - 2) Sections that cover the equipment for which Owner will provide applications software.
- 10. Coordination with Division 40, Process Integration, for valve actuators, fiber optic communication system and control interfaces. Refer to specific sections in Division 40, Process Integration, for information on equipment and details of that equipment available for PICS review, coordination and use. These systems will be tested and started up as part of this Contract by Contractor with significant assistance from the associated actuator supplier. The scope of services during construction required for valve actuator systems, may include, but is not limited to, installation coordination, installation testing, Functional Test Part 1 and Part 2 submittals, Functional Test Part 1 and 2 testing, and PAT testing.
- 11. Coordination with Division 26, Electrical, for Adjustable Frequency Drives and Motor Control Center interfaces. Refer to specific sections in Division 26, Electrical, for information on equipment and details of these devices available for PICS review, coordination and use. These systems shall be tested and started up as part of this Contract by Contractor with significant assistance from the associated equipment supplier. The scope of services during construction required for electrical systems, may include, but is not limited to, installation coordination, installation testing, Functional Test Part 1 and Part 2 submittals, Functional Test Part 1 and 2 testing, and PAT testing.

C. Work not included in this Contract:

- 1. Developing of application software for PLCs and HMIs.
- 2. Establishing SCADA network communications from new PLCs to existing PLCs.
- 3. Configuring Ethernet Switches.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section and other PIC subsections:
 - 1. American National Standards Institute (ANSI).
 - 2. ASTM International (ASTM):
 - a. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 - b. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - c. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.

- d. B32, Standard Specification for Solder Metal.
- e. B88, Standard Specification for Seamless Copper Water Tube.
3. Deutsche Industrie-Norm (DIN): VDE 0611, Specification for modular terminal blocks for connection of copper conductors up to 1,000V ac and up to 1,200V dc.
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
5. International Society of Automation (ISA):
 - a. RP12.06.01, Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety.
 - b. S5.1, Instrumentation Symbols and Identification.
 - c. S5.4, Instrument Loop Diagrams.
 - d. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
 - e. TR20.00.01, Specification Forms for Process Measurement and Control Instruments, Part 1: General.
6. International Conference on Energy Conversion and Application (ICECA).
7. National Electrical Code (NEC).
8. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. ICS 1, Industrial Control and Systems General Requirements.
9. National Fire Protection Association (NFPA): 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
10. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
11. Underwriters Laboratory, Inc. (UL): 508A, Standard for Safety, Industrial Control Panels.

1.03 DEFINITIONS

A. Abbreviations:

1. FDT: Factory Demonstration Test.
2. HMI: Human-Machine Interface.
3. HVAC: Heating, Ventilating, and Air Conditioning.
4. I&C: Instrumentation and Control.
5. I/O: Input and Output.
6. O&M: Operation and Maintenance.

7. P&ID: Process and Instrument Diagram.
 8. PC: Personal Computer.
 9. PIC: Process Instrumentation and Control.
 10. PLC: Programmable Logic Controller.
 11. RTU: Remote Terminal Unit.
 12. SCADA: Supervisory Control and Data Acquisition.
 13. SLDC: Single Loop Digital Controller.
 14. SSDT: Staging Site Demonstration Test.
 15. CCM: Control Cabinet in MCC room (Control Panel).
 16. NCP: Network Control Panel.
- B. System Integrator: Owner's separate contractor that will be providing application programming software for PLCs and HMIs and establishing SCADA network communications.
1. Scope of work that is outside of this Contract includes:
 - a. PLC programming.
 - b. Modification of plant SCADA software.
 - c. Configuration of Ethernet Switches specified in Section 40 95 80, Fiber Optic Communication System.
 - d. Software testing portion of Functional Test 2.
 - e. Coordination with Fiber Optic Communication System Contractor.
 - f. Coordination with PICS Subcontractor.
- C. PICS Subcontractor: Subcontractor that is doing the work specified in this section and Section 40 91 00, Instrumentation and Control Components.
- D. Enclosure: Control panel, console, cabinet, or instrument housing.
- E. Instructor Day: Eight hours of actual instruction time.
- F. Standard Software: Software packages that are independent of Project on which they are used. Standard software includes system software, supervisory control, and data acquisition (SCADA) software.
1. System Software: Application independent (non-project specific) software developed by digital equipment manufacturers and software companies. Includes, but is not limited to, operating systems; network support; Office Suites (word processor, spreadsheet, database, etc.); e-mail; security (firewall, antivirus; spam, spyware, etc.) debugging aids; and diagnostics.
 2. SCADA Software: Software packages independent of specific process control project on which they are used. Includes, but is not limited to, providing configuring and run-time capability for, data acquisition (I/O driver, OPC servers, etc.), monitoring, alarming, human-machine

- interface, supervisory control, data collection, data retrieval, trending, report generation, control, and diagnostics.
3. Controller Programming Software: Software packages for the configuring of PLCs, RTUs, DCUs, SLDC, and fieldbus devices.
- G. Application Software: Software to provide functions unique to this Project and that are not provided by standard software alone, including but not limited to:
1. Configuring databases, tables, displays, historians, reports, parameter lists, ladder logic, function block, and control strategies required to implement functions unique to this Project.
 2. Programming in any programming or scripting language.
- H. Rising/Falling: Define action of discrete devices about their setpoint.
1. Rising: Contacts close when an increasing process variable rises through setpoint.
 2. Falling: Contacts close when a decreasing process variable falls through setpoint.
- I. Signal Types:
1. Analog Signal, Current Type:
 - a. 4 to 20 mA dc signals conforming to ISA S50.1.
 - b. Unless otherwise indicated for specific PIC subsection components, use the following ISA S50.1 options.
 - 1) Transmitter Type: Number 2, two-wire.
 - 2) Transmitter Load Resistance Capacity: Class L.
 - 3) Fully isolated transmitters and receivers.
 2. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.
 3. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

1.04 SYSTEM DESCRIPTION

- A. Design Requirements:
1. Provide detailed design of PIC components and PIC drawings, including panel wiring diagrams, and loop wiring diagrams.
 2. Provide consistent hardware and software functions for PIC. For example, provide functions in control logic, sequence controls, and display layouts in same or similar manner.

3. PIC design as shown and specified includes:
 - a. Functional requirements, performance requirements, and component specifications.
 - b. P&IDs, block diagrams, and network diagrams.
 4. Typical drawings for installation details, panel power, and control diagrams.
- B. Use a qualified PICS Subcontractor for at least the following work:
1. For PIC Equipment and Ancillaries:
 - a. Completing detail design.
 - b. Submittals.
 - c. Equipment, enclosures, and ancillaries.
 - d. Instructions, details, and recommendations to, and coordination with Contractor for Certificate of Proper Installation.
 - e. Verify readiness for operation.
 - f. Verify correctness of final power and signal connections (lugging and connecting).
 - g. Adjusting and calibrating.
 - h. Starting up.
 - i. Testing and coordination of testing.
 - j. Training.
 - k. Assist Engineer with Functional Test Part 2 as defined in Article Field Quality Control.
 2. Verify following Work not by PICS Subcontractor is provided:
 - a. Correct type, size, and number of signal wires with their raceways.
 - b. Correct electrical power circuits and raceways.
 - c. Correct size, type, and number of PIC-related pipes, valves, fittings, and tubes.
 - d. Correct size, type, materials, and connections of process mechanical piping for in-line primary elements.
 3. NonPIC Equipment Directly Connected to PIC Equipment:
 - a. Obtain from Contractor, manufacturers' information on installation, interface, function, and adjustment.
 - b. Coordinate with Contractor to allow required interface and operation with PIC.
 - c. For operation and control, verify installations, interfacing signal terminations, and adjustments have been completed in accordance with manufacturer's recommendations.
 - d. Test to demonstrate required interface and operation with PIC.
 - e. Examples of items in this category, but not limited to the following:
 - 1) Valve operators, position switches, and controls.
 - 2) Chemical feed pump and feeder speed/stroke controls.

- 3) Motor control centers.
- 4) Adjustable speed and adjustable frequency drive systems.
- f. Examples of items not in this category:
 - 1) Internal portions of equipment provided under Division 26, Electrical, that are not directly connected to PIC equipment.
 - 2) Internal portions of package system instrumentation and controls that are not directly connected to PIC equipment.

1.05 SUBMITTALS

A. General:

1. Submit proposed Submittal breakdown consisting of sequencing and packaging of information in accordance with Project Schedule.
2. Partial Submittals not in accordance with Project Schedule will not be accepted.
3. Submittal Format: See Section 01 33 00, Contractor Submittals.
4. Identify proposed items, options, installed spares, and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
5. Legends and Abbreviation Lists:
 - a. Definition of symbols and abbreviations used; for example, engineering units, flowstreams, instruments, structures, and other process items used in nameplates, legends, data sheets, point descriptions, HMI displays, alarm/status logs, and reports.
 - b. Use identical abbreviations in PIC subsections.
 - c. Submit updated versions as they occur.
6. Activity Completion:
 - a. Action Submittals: Completed when reviewed and approved.
 - b. Informational Submittals: Completed when reviewed and found to meet conditions of the Contract.

B. Action Submittals:

1. Bill of Materials: List of required equipment.
 - a. Group equipment items by enclosure and field, and within an enclosure, as follows:
 - 1) PIC Components: By component identification code.
 - 2) Other Equipment: By equipment type.
 - b. Data Included:
 - 1) Equipment tag number.
 - 2) Description.
 - 3) Manufacturer, complete model number and all options not defined by model number.
 - 4) Quantity supplied.

- 5) Component identification code where applicable.
 - 6) For panels, include panel reference number and name plate inscription.
2. Catalog Cuts: I&C components, electrical devices, and mechanical devices:
 - a. Catalog information, marked to identify proposed items and options.
 - b. Descriptive literature.
 - c. External power and signal connections.
 - d. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
 3. Component Data Sheets: Data sheets for I&C components.
 - a. Format:
 - 1) Similar to ISA TR20.00.01.
 - 2) Microsoft Excel, one component per data sheet.
 - 3) Submit proposed format for Component Data Sheets before completing data sheets for individual components.
 - b. Content: Specific features and configuration data for each component, including but not limited to:
 - 1) Tag Number.
 - 2) Component type identification code and description.
 - 3) Location or service.
 - 4) Service conditions.
 - 5) Manufacturer and complete model number.
 - 6) Size and scale range.
 - 7) Setpoints.
 - 8) Materials of construction.
 - 9) Options included.
 - 10) Power requirements.
 - 11) Signal interfaces.
 - 12) Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
 4. Sizing and Selection Calculations:
 - a. Primary Elements: Complete calculations plus process data used. Example for Flow Elements:
 - 1) Minimum and maximum values, permanent head loss, and assumptions made.
 - b. Controller, Computing, and Function Generating Modules: Actual scaling factors with units and how they were computed.
 5. Preliminary Panel Elevation Drawings: Provide prior to submitting Panel Construction Drawings:
 - a. Scale Drawings: Show dimensions and location of front of panel devices.

- b. Panel Legend (Bill of Material): List front of panel devices by tag number. Include nameplate inscriptions, service legends, and annunciator inscriptions.
- c. Submit electronic copies of Drawings.
6. Panel Construction Drawings:
 - a. Scale Drawings: Show dimensions and locations of panel-mounted devices, doors, louvers, subpanels, internal and external.
 - b. Panel Legend (Bill of Material): List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
 - c. Bill of Materials: List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.
 - d. Construction Details: NEMA rating, materials, material thickness, structural stiffeners and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other connection callouts and details.
 - e. Construction Notes: Finishes, wire color schemes, wire ratings, wire, terminal block numbering, and labeling scheme.
 - f. Submit electronic copies of Drawings.
7. Panel Wiring Diagrams:
 - a. Cover wiring within a panel including, but not limited to, instrumentation, control, power, and communications, and digital networks.
 - b. Objectives: For use in wiring panels, making panel connections, and future panel trouble shooting.
 - c. Diagram Type:
 - 1) Ladder diagrams where applicable. Include devices that are mounted in or on the panel that require electrical connections. Show unique rung numbers on left side of each rung.
 - 2) Schematic drawings for wiring of circuits that cannot be well represented by ladder diagrams.
 - d. Item Identification: Identify each item with attributes listed.
 - 1) Wires: Wire number and color. Cable number if part of multiconductor cable.
 - 2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
 - 3) Components:
 - a) Tag number, terminal numbers, and location (“FIELD”, enclosure number, or MCC number).

- b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description (for example, Sump Level High).
- 4) I/O Points: PLC unit number, I/O tag number, I/O address, terminal numbers, and terminal strip numbers.
- 5) Relay Coils:
 - a) Tag number and its function.
 - b) On right side of run where coil is located, list contact location by ladder number and sheet number.
Underline normally closed contacts.
- 6) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
- 7) Communications and Networks: Network type, address or node identification, port or channel number, and type of connector.
- e. Show each circuit individually. No “typical” diagrams or “typical” wire lists will be allowed.
- f. Ground wires, surge protectors, and connections.
- g. Wire and Cable Names: Show names and wire color for circuits entering and leaving a panel. Refer to Division 26, Electrical.
- 8. Loop Wiring Diagrams: Individual, end-to-end wiring diagram for each analog and discrete or equipment loop.
 - a. Conform to the minimum requirements of ISA S5.4.
 - b. Under Paragraph 5.3 of ISA S5.4, include the information listed under Subparagraphs 2 and 6.
 - c. Show loop components within a panel and identify each component, component terminals, and panel terminals.
 - d. If a loop connects to panels or devices not provided under this section and its subsections, such as control valves, motor control centers, package system panels, variable speed drives, include the following information:
 - 1) Show the first component connected to within the panel or device that is not provided under this section and its subsections.
 - 2) Identify the component by tag and description.
 - 3) Identify panel and component terminal numbers.
 - e. Drawing Size: Individual 11-inch by 17-inch sheet for each loop.
 - f. Divide each loop diagram into areas for panel face, back-of-panel, field and PLC.
 - g. One Drawing Per Loop: Show each loop individually. No “typical” loop diagrams will be allowed.
 - h. Show:
 - 1) Terminal numbers, location of dc power supply, and location of common dropping resistors.

- 2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
 - 3) Tabular summary on each analog loop diagram:
 - a) Transmitting Instruments: Output capability.
 - b) Receiving Instruments: Input impedance.
 - c) Loop Wiring Impedance: Estimate based on wire sizes and lengths shown.
 - d) Total loop impedance.
 - e) Reserve output capacity.
 - 4) Circuit and raceway schedule names.
9. Communications and Digital Networks Diagrams:
- a. Scope: Includes connections to telephone system, SCADA network, security network, power monitoring network, fire alarm network, and Ethernet network.
 - b. Format: Network schematic diagrams for each different type of network.
 - c. Show:
 - 1) Interconnected devices, both passive and active.
 - 2) Device names and numbers.
 - 3) Terminal numbers.
 - 4) Communication Media: Type of cable.
 - 5) Connection Type: Type of connector.
 - 6) Node and device address numbers.
 - 7) Wire and cable numbers and colors.
10. Panel Power Requirements and Heat Dissipation: For control panels tabulate and summarize:
- a. Required voltages, currents, and phases(s).
 - b. Maximum heat dissipations Btu per hour.
 - c. Calculations.
 - d. Steady State Temperature Calculations: For nonventilated panels, provide heat load calculations showing the panel estimated internal steady state temperature for ambient air temperatures of 90 degrees F.
11. Installation Details: Include modifications or further details required and define installation of I&C components.
12. Spares, expendables, and test equipment.
13. Electronic Copies: Microsoft Excel.
14. PLC I/O List:
- a. Managed by Contractor:
 - 1) During construction Contractor will maintain PLC I/O List and give electronic Microsoft Excel copies to Engineer.
 - 2) Contractor will assign PLC I/O points to specific chassis, slot, and point addresses.

- b. PLC I/O List Changes: Changes to PLC I/O List reflecting actual equipment and instrumentation provided.
 - 1) Mark up electronic file of latest PLC I/O List from Engineer. Highlight changed cells with yellow, new rows with red, and rows to be deleted with green.
 - 2) Submit marked up copies changes at 30-day intervals.
- 15. Shop Drawings for Changes Impacting PLC Programming:
 - a. Submit details of changes required to PLC monitoring and control resulting from installation of alternative or upgraded process equipment and instrumentation, and other causes.
 - b. Submit changes at 30-day intervals.

C. Informational Submittals:

- 1. Statements of Qualification:
 - a. PICS Subcontractor.
 - b. PICS Subcontractor's site representative.
 - c. Resume for each PICS Subcontractor's onsite startup and testing team member (engineers, technicians, and software/configuring personnel).
- 2. Operation and Maintenance Data: In accordance with Section 01 76 00, Operating and Maintenance Information, and in addition the following:
 - a. General: Provide sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for PIC components.
 - b. Final versions of Legend and Abbreviation Lists.
 - c. Process and Instrumentation Diagrams: Marked up copy of revised P&ID to reflect as-built PIC design.
 - d. Provide the following items as defined under heading Action Submittals:
 - 1) Bill of materials.
 - 2) Catalog cuts.
 - 3) Instrument list.
 - 4) Component data sheets.
 - 5) Detailed Wiring Diagrams: Marked up copy of revised drawings to reflect as-built design.
 - a) Panel wiring diagrams.
 - b) Loop diagrams.
 - c) Interconnecting wiring diagrams.
 - 6) Panel plumbing diagrams.
 - e. Manufacturer's O&M manuals for components, electrical devices, and mechanical devices:
 - 1) Content for Each O&M Manual:
 - a) Table of Contents.
 - b) Operations procedures.

- c) Installation requirements and procedures.
 - d) Maintenance requirements and procedures.
 - e) Troubleshooting procedures.
 - f) Calibration procedures.
 - g) Internal schematic and wiring diagrams.
 - h) Component and I/O Module Calibration Sheets from field quality control calibrations.
 - 2) Provide PDF file with linked index to all manuals.
- f. List of spares, expendables, test equipment and tools provided.
- g. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.
- 3. Provide Manufacturer's Certificate of Proper Installation where specified.
- 4. Testing Related Submittals:
 - a. Factory Demonstration Test:
 - 1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
 - 2) Final Test Procedures:
 - a) Proposed test procedures, forms, and checklists.
 - b) Capacity, Timing, and Simulation: Describe simulation and monitoring methods used to demonstrate compliance with capacity and timing requirements.
 - 3) Test Documentation: Copy of signed off test results.
 - b. Functional Test:
 - 1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
 - 2) Final Test Procedures: Proposed test procedures, forms, and checklists.
 - 3) Test Documentation:
 - a) Copy of signed-off test results.
 - b) Completed component calibration sheets.
 - c. Performance Test:
 - 1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
 - 2) Final Test Procedures: Proposed test procedures, forms, and checklists.
 - 3) Test Documentation: Copy of signed-off test results.
- 5. Owner Training Plan: In accordance with Section 01 43 33, Manufacturers' Field Services.
- 6. Maintenance Service Agreement: Prior to Substantial Completion, submit service agreements signed by Owner and maintenance provider for work required under Article Maintenance Service.

1.06 QUALITY ASSURANCE

A. Qualifications:

1. PICS Subcontractor: Minimum of 10 years' experience providing, integrating, installing, and starting up similar systems as required for this Project.
2. PICS Subcontractor's Site Representative: Minimum of 5 years' experience installing systems similar to PIC required for this Project.

B. PIC Coordination Meetings:

1. General: Refer to Section 01 31 19, Communication and Project Meetings, for PIC coordination meetings.
2. PIC Schedule Coordination Meeting:
 - a. Timing: Following Engineer review of PIC Schedule.
 - b. Purpose: Discuss Engineer's comments and resolve scheduling issues.
3. Training Coordination Meeting:
 - a. Timing: Following Engineer review of preliminary training plan.
 - b. Purpose:
 - 1) Resolve required changes to proposed training plan.
 - 2) Identify specific Owner personnel to attend training.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. In accordance with Section 01 61 00, Common Product Requirements.
- B. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.
- C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.
- D. Cover panels and other elements that are exposed to dusty construction environments.

1.08 SEQUENCING AND SCHEDULING

- A. Refer to Section 01 31 30, Construction and Schedule Constraints, for Contractor's scheduling requirements for applications software testing.

- B. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and lead times listed below have been completed and satisfied:
1. Shop Drawing Reviews by Engineer:
 - a. Prerequisite: Engineer acceptance of Schedule of Values and Progress Schedule.
 - b. Schedule: In accordance with completed schedule of Shop Drawing and Sample submittals specified in Section 01 33 00, Contractor Submittals.
 2. Test Prerequisite: Associated test procedures Submittals completed.
 3. Training Prerequisite: Associated training plan Submittal completed.
 4. PLC and HMI Configuring Equipment Delivered to System Integrator's Office:
 - a. See Equipment Groups in Part 2 of this section for definition of equipment to be delivered.
 5. PLC and HMI Configuring Equipment Demonstration Test Prerequisite: PLC and HMI configuring equipment delivered and installed at System Integrator's office.
 6. PLC and HMI Applications Software Configuring by System Integrator at System Integrator's Office.
 - a. Prerequisite: PLC and HMI configuring equipment demonstration test.
 7. PLC and HMI Shipment to Site:
 - a. General Prerequisites:
 - 1) Approval of PIC Shop Drawings and preliminary operation and maintenance data.
 - 2) FDT completed.
 8. PLC and HMI Installation Prerequisite: Equipment received at Site.
 9. Functional Test Part 1 Prerequisite: PLC and HMI installation complete.
 10. Functional Test Part 2 Prerequisite:
 - a. Functional Test Part 1 completed.
 - b. Fiber Optic Cable Functional Test completed per Section 40 95 80, Fiber Optic Communication System.
 - c. Communication Functional Test completed per Section 40 95 80, Fiber Optic Communication System.
 11. Performance Test Prerequisite: Functional Test Part 2 completed and facility started up.

1.09 EXTRA MATERIALS

- A. As specified in PIC subsections.
- B. In computing spare parts quantities based on specified percentages, round up to nearest whole number.

C. Spare Parts:

Component (Code)	Quantity	Options
Dissolved Oxygen Probes	3	Range: 0-10 ppm

D. Expendables: For following items provide manufacturer’s recommended 2-year supply, unless otherwise noted.

1. Chemical for analyzers.
2. Corrosion-inhibiting vapor capsules.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide PIC functions shown on Drawings and required in PIC subsections for each system and loop. Furnish equipment items required in PIC subsections. Furnish materials, equipment, and software (except for System Integrator provided applications software), whether indicated or not, necessary to effect required system and loop performance.
- B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment, materials, and software.
 1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with the General Conditions, Article 6.05 Substitutes and “Or-Equals”.
 2. If proposed item requires, but not limited to, different installation, wiring, raceway, enclosures, intrinsically safe barriers, and accessories, provide such equipment and work.
- C. Like Equipment Items:
 1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer’s services.
 2. Implement same or similar functions in same or similar manner. For example control logic, sequence controls, and display layouts.

2.02 I&C COMPONENTS

- A. Specifications: Refer to Section 40 91 00, Instrumentation and Control Components, for specifications for I&C components.

- B. Components for Each Loop: Major components for each loop are listed in Instrument List referenced in Article Supplements. Furnish equipment that is necessary to achieve required loop performance.
- C. Control Panels: Reference Control Panel Schedule in Article Supplements.

2.03 PROGRAMMABLE LOGIC CONTROLLERS

- A. PLC Equipment: Reference PLC Equipment List in Article Supplements.
- B. Software:
 - 1. Provide latest version of SCADA software and required licensing as applicable for each PLC. Software and licensing shall be purchased in the name of the Owner to enable easy transition of ownership.
 - 2. Provide one copy of latest version of controller programming software and licensing as applicable. Software and licensing shall be purchased in the name of the Owner to enable easy transition of ownership.

2.04 NETWORK, AND HMI COMPONENTS

- A. See Section 40 91 00, Instrumentation and Control Components.

2.05 SERVICE CONDITIONS

- A. Standard Service Conditions: The following defines certain types of environments. PIC subsections refer to these definitions by name to specify the service conditions for individual equipment units. Design equipment for continuous operation in these environments:
 - 1. Inside, Air Conditioned:
 - a. Temperature:
 - 1) Normal: 60 degrees F to 80 degrees F.
 - 2) With Up to 4-Hour HVAC System Interruptions: 40 degrees F to 105 degrees F.
 - b. Relative Humidity:
 - 1) Normal: 10 percent (winter) to 70 percent (summer).
 - 2) With Up to 4-Hour HVAC System Interruption: 10 percent to 100 percent.
 - c. NEC Classification: Nonhazardous.
 - 2. Inside:
 - a. Temperature: 20 degrees F to 104 degrees F.
 - b. Relative Humidity: 10 percent to 95 percent noncondensing.
 - c. NEC Classification: Nonhazardous.

3. Inside, Corrosive:
 - a. Temperature: Minus 20 degrees F to 104 degrees F.
 - b. Relative Humidity: 10 percent to 100 percent.
 - c. Corrosive Environment: Ferric Chloride storage and handling.
 - d. NEC Classification: Nonhazardous.
 4. Inside, Hazardous:
 - a. Temperature: Minus 20 degrees F to 104 degrees F.
 - b. Relative Humidity: 10 percent to 100 percent. 10 percent to 95 percent noncondensing.
 - c. NEC Classification: Class 1, Division 1, Group D. As shown on Area Classification and Material Selection Table.
 5. Outside:
 - a. Temperature: Minus 20 degrees F to 104 degrees F.
 - b. Relative Humidity: 10 percent to 100 percent, rain, snow, freezing rain.
 - c. NEC Classification: Nonhazardous.
 6. Outside, Corrosive:
 - a. Temperature: Minus 20 degrees F to 104 degrees F.
 - b. Relative Humidity: 0 to 100 percent, rain, snow, freezing rain.
 - c. Corrosive Environment: Misting waste water.
 - d. NEC Classification: Nonhazardous.
 7. Outside, Hazardous:
 - a. Temperature: Minus 20 degrees F to 104 degrees F.
 - b. Relative Humidity: 0 to 100 percent, rain, snow, freezing rain.
 - c. NEC Classification: As shown on Area Classification and Material Selection Table.
- B. Standard Service Conditions for Panels and Consoles: Unless otherwise noted, in Instrument List and Control Panel Schedule located in Article Supplements at End of Section, design equipment for continuous operation in these environments:
1. Freestanding Panel and Consoles:
 - a. Inside, Air Conditioned: NEMA 1.
 - b. Inside: NEMA 12.
 2. Smaller Panels and Assemblies (that are not freestanding):
 - a. Inside, Air Conditioned: NEMA 12.
 - b. All Other Locations: NEMA 4X.
 3. Field Elements: Outside.
- C. Special Environmental Requirements: Design following panels for continuous operation in environments listed.

2.06 NAMEPLATES AND TAGS

- A. Panel Nameplates: Enclosure identification located on enclosure face.
 - 1. Location and Inscription: As shown on Drawings.
 - 2. Materials: Laminated plastic attached to panel with stainless steel screws.
 - 3. Letters: 1/2-inch-high, white on black background, unless otherwise noted.

- B. Component Nameplates, Panel Face: Component identification located on panel face under or near component.
 - 1. Location and Inscription: As shown on panel drawing.
 - 2. Materials: Adhesive-backed, laminated plastic.
 - 3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

- C. Component Nameplates, Back of Panel: Component identification located on or near component inside of enclosure.
 - 1. Inscription: Component tag number.
 - 2. Materials: Adhesive-backed, laminated plastic.
 - 3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

- D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.
 - 1. Inscription:
 - a. Refer to table under Paragraph Standard Pushbutton Colors and Inscriptions.
 - b. Refer to table under Paragraph Standard Light Colors and Inscriptions.
 - c. Refer to P&IDs on Drawings.
 - 2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
 - 3. Letters: Black on gray or white background.

- E. Service Legends: Component identification nameplate located on face of component.
 - 1. Inscription: As shown on panel drawing.
 - 2. Materials: Adhesive-backed, laminated plastic.
 - 3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

- F. Nametags: Component identification for field devices.
 - 1. Inscription: Component tag number.
 - 2. Materials: 16-gauge, Type 304 stainless steel.
 - 3. Letters: 3/16-inch-high, imposed.
 - 4. Mounting: Affix to component with 16-gauge or 18-gauge stainless steel wire or stainless steel screws.

2.07 MECHANICAL SYSTEM COMPONENTS

- A. Reference Section 40 91 00, Instrumentation and Control Components.

2.08 FUNCTIONAL REQUIREMENTS FOR CONTROL LOOPS

- A. Shown on Drawings, in panel control diagrams, and Process and Instrumentation Diagrams (P&ID). P&ID format and symbols are in accordance with ISA S5.1, except as specified or shown on Drawings.

2.09 ELECTRICAL REQUIREMENTS

- A. Electrical Raceways: As specified in Section 26 05 33, Raceway and Boxes.
- B. Wiring External to PIC Equipment:
 - 1. Special Control and Communications Cable: Provided by PICS Subcontractor as noted in Component Specifications and PIC subsections.
 - 2. Other Wiring and Cable: As specified in Section 26 05 05, Conductors.
- C. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.
- D. Wires within Enclosures:
 - 1. ac Circuits:
 - a. Type: 600-volt, Type MTW stranded copper.
 - b. Size: For current to be carried, but not less than No. 18 AWG.
 - 2. Analog Signal Circuits:
 - a. Type: 600-volt stranded copper, twisted shielded pairs or triad with a 100 percent, aluminum-polyester shield, rated 60 degrees C.
 - b. Panels with Circuits Less Than 600 volts: Rated at 600 volts. Belden No. 18 AWG Type 9341, Triad Belden No. 1121A.
 - c. Size: No. 18 AWG, minimum.

3. Other dc Circuits.
 - a. Type: 600-volt, Type MTW stranded copper.
 - b. Size: For current carried, but not less than No. 18 AWG.
 4. Special Signal Circuits: Use manufacturer's standard cables.
 5. Wire Identification: Numbered and tagged at each termination.
 - a. Wire Tags: Machine printed, heat shrink.
 - b. Manufacturers:
 - 1) Brady Perma Sleeve.
 - 2) Tyco Electronics.
- E. Terminate and identify wires entering or leaving enclosures as follows:
1. Analog and discrete signal, terminate at numbered terminal blocks.
 2. Special signals terminated using manufacturer's standard connectors.
 3. Identify wiring in accordance with requirements in Section 26 05 05, Conductors.
- F. Terminal Blocks for Enclosures:
1. Quantity:
 - a. Accommodate present and spare indicated needs.
 - b. Wire spare PLC I/O points to terminal blocks.
 - c. One wire per terminal for field wires entering enclosures.
 - d. Maximum of two wires per terminal for No. 18 AWG wire for internal enclosure wiring.
 - e. Spare Terminals: 20 percent of connected terminals, but not less than 5/10 per terminal block, unless otherwise shown on Drawings.
 2. Terminal Block Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Article Electrical Components.
- G. Grounding of Enclosures:
1. Furnish isolated copper grounding bus for signal and shield ground connections.
 2. Ground this ground bus at a common signal ground point in accordance with National Electrical Code requirements.
 3. Single Point Ground for Each Analog Loop:
 - a. Locate signal ground at dc power supply for loop.
 - b. Use to ground wire shields for loop.
 - c. Group and ground wire shields in following locations: CCM panels.
 4. Ground terminal block rails to ground bus.

- H. Analog Signal Isolators:
1. Furnish signal isolation for analog signals that are sent from one enclosure to another.
 2. Do not wire in series instruments on different panels, cabinets, or enclosures.
- I. Intrinsic Safety System Installation:
1. Comply with NEC Article 504, Intrinsically Safe Systems.
 2. Install intrinsically safe circuits in a separate wire way that:
 - a. Is separated from nonintrinsically safe circuits as specified by NEC.
 - b. Is colored light blue and has message “Intrinsically Safe Circuits Only” on raceway cover every 6 inches.
- J. Wiring Interface: Terminate and identify wiring entering or leaving enclosures.
1. Analog and Discrete Signal Wires: Terminate at numbered terminal blocks as shown on the wiring diagrams.
 2. Wiring for Special Signals: Terminate communications, digital data, and multiplexed signals using manufacturer’s standard connectors for the device to which the signals terminate.
- K. Electrical Transient Protection:
1. General:
 - a. Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
 - b. Provide, install, coordinate, and inspect grounding of surge suppressors at:
 - 1) Connection of ac power to panels with PLC equipment or Network equipment.
 2. Surge Suppressor Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Surge Suppressors.
 3. Installation and Grounding of Suppressors: Provide a surge protective device for the incoming power for each CCM

2.10 PANEL FABRICATION

A. General:

1. Nominal Panel Dimensions: Refer to Control Panel Schedule in Article Supplements for maximum external dimensions allowed for individual control panels.
2. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), state and local codes, and applicable sections of NEMA, ANSI, UL, and ICECA.
3. Fabricate panels, install instruments and wire, and plumb at PICS Subcontractor's facility. No fabrication other than correction of minor defects or minor transit damage permitted onsite.
4. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" per UL 508A.
5. Electrical Work: In accordance with the applicable requirements of Division 26, Electrical.

B. Temperature Control:

1. Freestanding Panels:
 - a. Nonventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel and on panel.
 - b. Ventilated Panels:
 - 1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel and on panel.
 - 2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
 - 3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
 - 4) Louver Construction: Stamped sheet metal.
 - 5) Ventilation Fans:
 - a) Furnish where required to provide adequate cooling.
 - b) Create positive internal pressure within panel.
 - c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
 - 6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
 - c. Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation.
2. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel and on panel face.

3. Space Heaters:
 - a. Thermostatically controlled to maintain internal panel temperatures above dewpoint.
 - b. Refer to Control Panel Schedule in Article Supplements.
- C. Freestanding Panel Construction:
1. Materials:
 - a. Sheet steel, unless otherwise noted in Control Panel Schedule in Article Supplements.
 - b. Minimum Thickness: 10-gauge, unless otherwise noted.
 2. Panel Front:
 - a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
 - b. No seams or bolt heads visible when viewed from front.
 - c. Panel Cutouts: Smoothly finished with rounded edges.
 - d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.
 3. Internal Framework:
 - a. Structural steel for instrument support and panel bracing.
 - b. Permit panel lifting without racking or distortion.
 4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.
 5. Adjacent Panels: Securely bolted together so front faces are parallel.
 6. Door:
 - a. Full height, fully gasketed access door where shown on Drawings.
 - b. Latch: Three-point, Southco Type 44.
 - c. Handle: "D" ring, foldable type.
 - d. Hinges: Full-length, continuous, piano-type, steel hinges with stainless steel pins.
 - e. Front Doors: As shown on Drawings.
- D. Nonfreestanding Panel Construction:
1. Based on environmental design requirements and referenced in Article Environmental Requirements, provide the following unless otherwise noted in Control Panel Schedule in Article Supplements:
 - a. Panels listed as inside, air conditioned:
 - 1) Enclosure Type: NEMA 12.
 - 2) Materials: Steel.
 - b. Other Panels:
 - 1) Enclosure Type: NEMA 4X.
 - 2) Materials: Fiberglass.

2. Doors:
 - a. Rubber-gasketed with continuous hinge.
 - b. Stainless steel lockable quick-release clamps.
 3. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. H. F. Cox.
- E. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels:
1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.
- F. Control Panel Electrical:
1. Power Distribution within Panels:
 - a. Feeder Circuits:
 - 1) One or more 120V ac, 60-Hz feeder circuits as shown on Drawings.
 - 2) Make provisions for feeder circuit conduit entry.
 - 3) Furnish terminal block for termination of wires.
 - b. Circuit Wiring: P&IDs and Control Diagrams on Drawings show function only. Use following rules for actual circuit wiring:
 - 1) Devices on Single Circuit: 20, maximum.
 - 2) Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
 - 3) Branch Circuit Loading: 12 amperes continuous, maximum.
 - 4) Panel Lighting and Service Outlets: Put on separate 15 amp, 120V ac branch circuit.
 - 5) Provide 120V ac plugmold for panel components with line cords.
 2. Signal Distribution:
 - a. Signal Wiring: Separate analog signal cables from power and control within a panel and cross at right angles where necessary.
 - b. Within Panels: 4 to 20 mA dc signals may be distributed as 1V dc to 5V dc.
 - c. Outside Panels: Isolated 4 to 20 mA dc only.
 - d. Signal Wiring: Twisted shielded pairs.
 - e. RTD and Thermocouple Extension Cable:
 - 1) Continuous field to panel with no intermediate junction boxes or terminations.
 - 2) RTDs in motor windings are considered a 600-volt circuit.
 - 3) Terminate thermocouple extension wire directly to loop instrument.

3. Relay Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Article Electrical Components.
4. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.
5. Internal Panel Lights for Freestanding Panels:
 - a. Type: Switched fluorescent top panel lights
 - b. Quantity: One light for every 4 feet of panel width.
 - c. Mounting: Inside and in the top of the control panel.
 - d. Protective acrylic diffusers for lights.
6. Service Outlets for Freestanding Panels:
 - a. Type: Three-wire, 120-volt, 15-ampere, GFCI duplex receptacles.
 - b. Quantity:
 - 1) Panels 4 Feet Wide and Smaller: One.
 - 2) Panels Larger than 4 Feet Wide: One for every 4 feet of panel width, two minimum per panel.
 - c. Mounting: Evenly spaced along back-of-panel area.
7. Internal Panel Lights and Service Outlets for Smaller Panels:
 - a. Internal Panel Light: Switched fluorescent light.
 - b. Service Outlet: Breaker protected 120-volt, 15-amp, GFCI duplex receptacle:
 - c. Required for panels. Refer to Control Panel Schedule in Article Supplements.
8. Standard Pushbutton Colors and Inscriptions:
 - a. Use following unless otherwise noted in Instrument List:

Tag Function	Inscription(s)	Color
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black
OCA	OPEN CLOSE AUTO	Black Black Black
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Black Black
RESET	RESET	Black

Tag Function	Inscription(s)	Color
EMERGENCY STOP	EMERGENCY STOP	Red

- b. Lettering Color:
 - 1) Black on white and yellow buttons.
 - 2) White on black, red, and green buttons.
- 9. Standard Light Colors and Incriptions:
 - a. Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted in Instrument List:

Tag Function	Inscription(s)	Color
ON	ON	Green
OFF	OFF	Red
OPEN	OPEN	Green
CLOSED	CLOSED	Red
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow

- b. Lettering Color:
 - 1) Black on white and amber lenses.
 - 2) White on red and green lenses.
- G. PIC Enclosure Internal Wiring:
1. Restrain by plastic ties or ducts or metal raceways.
 2. Hinge Wiring: Secure at each end so bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
 3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
 4. Provide abrasion protection for wire bundles that pass through holes or across edges of sheet metal.
 5. Connections to Screw Type Terminals:
 - a. Locking-fork-tongue or ring-tongue lugs.
 - b. Use manufacturer’s recommended tool with required sized anvil to make crimp lug terminations.

- c. Wires terminated in a crimp lug, maximum of one.
- d. Lugs installed on a screw terminal, maximum of two.
6. Connections to Compression Clamp Type Terminals:
 - a. Strip, prepare, and install wires in accordance with terminal manufacturer's recommendations.
 - b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.
7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
11. Plastic Wire Duct Fill: Do not exceed manufacturer's recommendations.
12. Conductors Carrying Foreign Voltages within a Panel:
 - a. Route foreign voltage conductors into panel and land on a circuit blade disconnect type terminal block.
 - b. Use wire with pink insulation to identify foreign voltage circuits within panel from terminal block on. Do not use wires with pink insulation for any other purpose.
13. Harness Wiring:
 - a. 120V ac: No. 14 AWG, MTW.
 - b. 24V dc: No. 16 AWG, MTW where individual conductors are used and Type TC shielded tray cable where shielded wire is used.
14. Panelwork:
 - a. No exposed connections.
 - b. Allow adjustments to equipment to be made without exposing these terminals.
15. Plastic Wire Ducts Color:
 - a. 120V ac: White.
 - b. 24V dc: Gray.
 - c. Communications Cables and Fiber Optic Jumpers: Orange.
16. Provide a communications plastic wire duct for communications cables and fiber optic cables between the communications devices in control panel and communications raceways. Design plastic wire duct design to take into account the minimum bending radius of the communications cable.
17. Make plastic wire ducts the same depth.
18. Provide a minimum of 1-1/2 inches between plastic wire ducts and terminal blocks.

- H. Control Relay Arrangement: Install control relays associated with specific loops in same panel section as corresponding terminal blocks or side panels. Provide 20 percent space for future relays. Locate spare space in same sections as spare terminal blocks.

- I. Factory Finishing:
 - 1. Furnish materials and equipment with manufacturer's standard finish system in accordance with Section 09 90 00, Painting and Coating.
 - 2. Use specific color if indicated. Otherwise use manufacturer's standard finish color, or light gray if manufacturer has no standard color.
 - 3. Stainless Steel and Aluminum: Not painted.
 - 4. Nonmetallic Panels: Not painted.
 - 5. Steel Panels:
 - a. Sand panel and remove mill scale, rust, grease, and oil.
 - b. Fill imperfections and sand smooth.
 - c. Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
 - d. Sand surfaces lightly between coats.
 - e. Dry Film Thickness: 3 mils, minimum.
 - f. Color: Manufacturer's standard.

2.11 CORROSION PROTECTION

- A. Corrosion-Inhibiting Vapor Capsules:
 - 1. Areas Where Required: Refer to Part 3, Article Protection.
 - 2. Manufacturers and Products:
 - a. Northern Instruments; Model Zerust VC.
 - b. Hoffmann Engineering; Model A-HCI.

2.12 EQUIPMENT GROUPS

- A. PLC Equipment Group 1 for System Integrator's Office.
 - 1. PLC rack
 - 2. Controller (CPU).
 - 3. Analog input module.
 - 4. Analog output module.
 - 5. Discrete input module.
 - 6. Discrete output module.
 - 7. Ethernet communication module.
 - 8. Ethernet switch.
 - 9. HMI.

2.13 SOURCE QUALITY CONTROL

A. General:

1. Engineer may actively participate in many of the tests.
2. Engineer reserves right to test or retest specified functions.
3. Engineer's decision will be final regarding acceptability and completeness of testing.
4. Procedures, Forms, and Checklists:
 - a. Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
 - b. Describe each test item to be performed.
 - c. Have space after each test item description for sign off by appropriate party after satisfactory completion.
5. Required Test Documentation: Test procedures, forms, and checklists signed by Engineer and Contractor.
6. Conducting Tests:
 - a. Provide special testing materials and equipment.
 - b. Wherever possible, perform tests using actual process variables, equipment, and data.
 - c. If not practical to test with real process variables, equipment, and data provide suitable means of simulation.
 - d. Define simulation techniques in test procedures.
 - e. Test Format: Cause and effect.
 - 1) Person conducting test initiates an input (cause).
 - 2) Specific test requirement is satisfied if correct result (effect), occurs.
 - f. For PIC systems for which Engineer provides applications software, provide sufficient temporary software configuring to allow FDT of these subsystems.

B. Unwitnessed Factory Test:

1. Scope: Inspect and test PIC to ensure it is operational, ready for FDT.
2. Location: PICS Subcontractor's facility.
3. Integrated Test:
 - a. Interconnect and test PIC, except for primary elements and smaller panels.
 - b. Exercise and test functions.
 - c. Provide stand-alone testing of smaller panels.
 - d. Simulate inputs and outputs for primary elements, final control elements, and panels excluded from test.

C. Factory Demonstration Tests (FDT):

1. Notify Engineer of test schedule 4 weeks prior to start of test.
2. Scope:
 - a. Test entire PIC, with exception of primary elements, final control elements, and certain smaller panels, to demonstrate it is operational.
 - b. Refer to Control Panel Schedule in Article Supplements for list of panels for which FDT is required.
3. Location: PICS Subcontractor's facility.
4. Correctness of wiring from panel field terminals to PLC system input/output points and to panel components.
 - a. Simulate each discrete signal at terminal strip.
 - b. Simulate correctness of each analog signal using current source.
5. Operation of communications between PLCs and remote I/O and between PLCs and computers.
6. Nonloop-Specific Functions:
 - a. Capacity: Demonstrate that PIC systems have required spare capacity for expansion. Include tests for both storage capacity and processing capacity.
 - b. Timing: Include tests for timing requirements.
 - c. Diagnostics: Demonstrate online and offline diagnostic tests and procedures.
7. Correct deficiencies found and complete prior to shipment to Site.
8. Failed Tests:
 - a. Repeat and witnessed by Engineer.
 - b. With approval of Engineer, certain tests may be conducted by PICS Subcontractor and witnessed by Engineer as part of Functional Test.
9. Make following documentation available to Engineer at test site both before and during FDT:
 - a. Drawings, Specifications, Addenda, and Change Orders.
 - b. Master copy of FDT procedures.
 - c. List of equipment to be tested including make, model, and serial number.
 - d. Approved hardware Shop Drawings for equipment being tested.
 - e. Approved preliminary software documentation Submittal.
10. Daily Schedule for FDT:
 - a. Begin each day with meeting to review day's test schedule.
 - b. End each day with each meeting to review day's test results and to review or revise next day's test schedule.
11. Coordinate with System Integrator to obtain PLC hardware back as required.

2.14 MAINTENANCE OF PROGRAMMING EQUIPMENT

- A. Provide for maintenance of programming equipment while at System Integrator’s office. Repair or replace failed equipment within 2 days of notice by Engineer.

PART 3 EXECUTION

3.01 EXAMINATION

- A. For equipment not provided by PICS Subcontractor Integrator, but that directly interfaces with PIC, verify the following conditions:
 - 1. Proper installation.
 - 2. Calibration and adjustment of positioners and I/P transducers.
 - 3. Correct control action.
 - 4. Switch settings and dead bands.
 - 5. Opening and closing speeds and travel stops.
 - 6. Input and output signals.

3.02 INSTALLATION

- A. Material and Equipment Installation: Follow manufacturers’ installation instructions, unless otherwise indicated or directed by Engineer.
- B. Wiring connected to PIC components and assemblies, including power wiring in accordance with requirements in Section 26 05 05, Conductors.
- C. All field instruments requiring 120Vac and 24Vdc power shall be powered from UPS power in associated control panel (CCM).
- D. Electrical Raceways: As specified in Section 26 05 33, Raceway and Boxes.
- E. Field Finishing: Refer to Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

- A. General:
 - 1. Coordinate PIC testing with Owner, System Integrator and affected Subcontractors.
 - 2. Notify Engineer of Performance Test schedule 4 weeks prior to start of test.
 - 3. Engineer may actively participate in tests.
 - 4. Engineer reserves right to test or retest specified functions.
 - 5. Engineer’s decision will be final regarding acceptability and completeness of testing.

B. Onsite Supervision:

1. Require PICS Subcontractor to observe PIC equipment installation to extent required in order to provide Certificates of Proper Installation.
2. Require PIC site representative to supervise and coordinate onsite PIC activities.
3. Require PIC site representative to be onsite while onsite work covered by this section and PIC subsystems is in progress.

C. Testing Sequence:

1. Provide Functional Tests and Performance Tests for facilities as required to support staged construction and startup of plant.
2. Refer to article Sequence of Work under Section 01 31 30, Construction and Schedule Constraints, for a definition of project milestones.
3. Refer to Section 01 75 00, Testing, Equipment Startup, and Commissioning, for overall testing requirements.
4. Completion: When tests have been completed and required test documentation has been accepted.

D. Testing:

1. Prior to Facility Startup and Performance Evaluation period for each facility, inspect, test, and document that associated PIC equipment is ready for operation. Divide Functional Test for each facility into two parts.
2. Functional Test Part 1: Performed by PICS Subcontractor to test and document PIC, excluding System Integrator provided applications software, is ready for operation.
 - a. Temporary Software for Testing:
 - 1) For PIC Subsystems for which System Integrator provides applications software, provide sufficient temporary software configuring to allow testing of these subsystems.
 - 2) Alternatives to providing temporary software for testing will need to be approved by Engineer. Alternatives must demonstrate that PICS is functional.
 - b. Loop/Component Inspections and Tests:
 - 1) These inspections and tests do not require witnessing will be spot checked by Engineer.
 - 2) Check PIC for proper installation, calibration, and adjustment on loop-by-loop and component-by-component basis.
 - 3) Provide space on forms for signoff by PICS Subcontractor.

- 4) Use loop status report to organize and track inspection, adjustment, and calibration of each loop and include the following:
 - a) Project name.
 - b) Loop number.
 - c) Tag number for each component.
 - d) Checkoffs/Signoffs for Each Component:
 - (1) Tag/identification.
 - (2) Installation.
 - (3) Termination wiring.
 - (4) Termination tubing.
 - (5) Calibration/adjustment.
 - e) Checkoffs/Signoffs for the Loop:
 - (1) Panel interface terminations.
 - (2) I/O interface terminations with PLCs.
 - f) I/O Signals for PLCs, RTUs are Operational:
Received/sent, processed, adjusted.
 - g) Total loop operational.
 - h) Space for comments.
- 5) Component calibration sheet for each active I&C component (except simple hand switches, lights, gauges, and similar items) and each PLCs, I/O module and include the following:
 - a) Project name.
 - b) Loop number.
 - c) Component tag number or I/O module number.
 - d) Component code number for I&C elements.
 - e) Manufacturer for I&C elements.
 - f) Model number/serial number for I&C elements.
 - g) Summary of Functional Requirements; For Example:
 - (1) Indicators and recorders, scale and chart ranges.
 - (2) Transmitters/converters, input and output ranges.
 - (3) Computing elements' function.
 - (4) Controllers, action (direct/reverse) and control modes (P, I, D).
 - (5) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
 - (6) I/O Modules: Input or output.
 - h) Calibrations, for example, but not limited to:
 - (1) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
 - (2) Discrete Devices: Actual trip points and reset points.

- (3) Controllers: Mode settings (P&ID).
 - (4) I/O Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling.
 - (5) Space for comments.
 - c. Maintain loop status reports, valve adjustment sheets, and component calibration sheets at Site, and make them available to Engineer at all times.
 - d. Engineer reviews loop status sheets and component calibration sheets and spot-check their entries periodically, and upon completion of Preparation for Testing. Correct deficiencies found.
 - e. FDT-Repeat:
 - 1) Repeat FDT onsite with installed PIC equipment and software.
 - 2) As listed in PIC subsections, certain portions of FDT may not require retesting.
 - 3) Use FDT test procedures as basis for this test.
 - 4) In general, this test shall not require witnessing. However, portions of this test, as identified by Engineer during original FDT shall be witnessed.
 - f. Forms: See Loop Status Report, Instrument Calibration Sheet, and I&C Valve Adjustment Sheet referenced in Article Supplements.
 3. Functional Test Part 2: Combined effort between Contractor, PICS Subcontractor, System Integrator, and Engineer to confirm PIC, including applications software, is ready for operation.
 - a. Prerequisite:
 - 1) Completion of Functional Test Part 1.
 - 2) Completion of Fiber Optic Cable Functional Test per Section 40 95 80, Fiber Optic Communication System.
 - 3) Completion of Communication Functional Test per Section 40 95 80, Fiber Optic Communication System.
 - b. Joint test with System Integrator.
 - c. Test procedures provided by Engineer based on Functional Test Part 1 and application software tests.
 - d. Completed when Functional Test has been conducted and Engineer has approved associated test forms and checklists in field.
 4. Required Test Documentation: Test procedures, forms, and checklists. Signed by Engineer and Contractor except for Functional Test items signed only by Contractor.
- E. Performance Test During and After Facility Startup:
1. Some control processes cannot be completely tested until the facility is up and treating waste. These functions require an additional performance testing after or during facility startup. Once a facility's

Functional Test has been completed, perform jointly with Engineer, and System Integrator. Make O&M data available to Engineer at Site both before and during testing.

2. Determination of Ready for Operation: When Functional Test has been completed.

3.04 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative: As required by each PIC subsection.
- B. Specialty Equipment: For certain components or systems provided under this section, but not manufactured by PICS Subcontractor, provide services of qualified manufacturer's representative during installation, startup, demonstration testing, and training. Provide original equipment manufacturer's services for:
 1. A20 Dissolved Oxygen Element and Transmitter Nonmembrane Luminescent (LDO).
 2. A30 Phosphate Analyzer and Transmitter.
 3. F51 Flow Element and Transmitter, Thermal Mass Flow.
- C. See Section 01 43 33, Manufacturers' Field Services, and Section 01 75 00, Testing, Equipment Startup, and Commissioning.

3.05 TRAINING

- A. General:
 1. Provide an integrated training program for Owner's personnel.
 2. Perform training to meet specific needs of Owner's personnel.
 3. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
 4. Provide instruction on one working shift(s) as needed to accommodate the Owner's personnel schedule.
 5. Owner reserves the right to reuse videotapes of training sessions.
- B. Operations and Maintenance Training:
 1. General:
 - a. Refer to specific requirements specified in PIC Subsections.
 - b. Include review of O&M data and survey of spares, expendables, and test equipment.
 - c. Use equipment similar to that provided.
 - d. Unless otherwise specified in PIC subsections, provide training suitable for instrument technicians with at least a 2-year associate

- engineering or technical degree, or equivalent education and experience in electronics, instrumentation, or digital systems.
2. Operations Training: For Owner's operations personnel on operation of I&C components.
 - a. Training Session Duration: 3 instructor days.
 - b. Number of Training Sessions: Three.
 - c. Maximum Session Duration: 4 hours.
 - d. Location: Project Site.
 - e. Course Objective: Develop skills needed to use I&C components and functions to monitor and control the plant on a day-to-day basis.
 - f. Content: Conduct training on loop-by-loop basis.
 - 1) Loop Functions: Understanding of loop functions, including interlocks for each loop.
 - 2) Loop Operation: For example, adjusting process variable setpoints, AUTO/MANUAL control transfer, AUTO and MANUAL control, annunciator acknowledgement and resetting.
 - 3) Interfaces with PIC subsystems.
 3. Maintenance Training:
 - a. Training Session Duration: 3 instructor days.
 - b. Number of Training Sessions: Three.
 - c. Maximum Session Duration: 4 hours.
 - d. Location: Project Site.
 - e. Course Objective: Develop skills needed for routine maintenance of PIC.
 - f. Content: Provide training for each type of component and function provided.
 - 1) Loop Functions: Understanding details of each loop and how they function.
 - 2) Component calibration.
 - 3) Adjustments: For example, controller tuning constants, current switch trip points, and similar items.
 - 4) Troubleshooting and diagnosis for equipment and software.
 - 5) Replacing lamps, chart paper, and fuses.
 - 6) I&C components removal and replacement.
 - 7) Periodic preventive maintenance.

3.06 CLEANING

- A. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.07 PROTECTION

- A. Use corrosion-inhibiting vapor capsules in enclosures to protect electrical, instrumentation, and control devices, including spare parts, from corrosion.
- B. Periodically replace capsules based on capsule manufacturer's recommendations.

3.08 SUPPLEMENTS

- A. Supplements listed below, follows "End of Section," are part of this Specification.
 - 1. PLC Equipment List.
 - 2. Control Panel Schedule.
 - 3. Preparation for Testing and Functional Test Forms:
 - a. Loop Status Report: Each sheet shows status of instruments on a loop. Also, gives functional description for loop.
 - b. Instrument Calibration Sheet: Shows details on each instrument (except simple hand switches, lights, and similar items).
 - c. I&C Valve Adjustment Sheet: Shows details for installation, adjustment, and calibration of a given valve.
 - 4. Performance Test Sheet: Describe Performance Test for a given loop.
 - a. List requirements of the loop.
 - b. Briefly describe test.
 - c. Cite expected results.
 - d. Provide space for checkoff by witness.
 - 5. Instrument List.
 - 6. PLC Input/Output List.

END OF SECTION

PLC EQUIPMENT LIST					
Name	Description	Qty.	Model	Manufacturer	Comments
3095PLCPEP	PROGRAMMABLE CONTROLLER		See 40 91 00	See 40 91 00	
	Power Supply	AR	See 40 91 00	See 40 91 00	Provide a spare power supply in addition to what is required in the I/O list.
	Controller Module	1	See 40 91 00	See 40 91 00	Ethernet and RS-232 communication ports. Provide a spare controller in addition to what is required for the project.
	Isolated Analog Input Module	AR	See 40 91 00	See 40 91 00	Provide a spare module in addition to what is required in the I/O list.
	Analog Output Module	AR	See 40 91 00	See 40 91 00	Provide a spare module in addition to what is required in the I/O list.
	Discrete Input Module	AR	See 40 91 00	See 40 91 00	Provide a spare module in addition to what is required in the I/O list.
	Digital Output Module	AR	See 40 91 00	See 40 91 00	Provide a spare module in addition to what is required in the I/O list.
	24V dc power supply	2		Phoenix Contact	Each power supply shall be suitable to supply all 24V power requirements.
	Diode Redundancy Module	1	Quint-Diode/12-24DC	Phoenix Contact	

PLC EQUIPMENT LIST					
Name	Description	Qty.	Model	Manufacturer	Comments
4483PLCBB	PROGRAMMABLE CONTROLLER		See 40 91 00	See 40 91 00	
	Power Supply	AR	See 40 91 00	See 40 91 00	
	Controller Module	1	See 40 91 00	See 40 91 00	Ethernet and RS-232 communication ports
	Isolated Analog Input Module	AR	See 40 91 00	See 40 91 00	
	Analog Output Module	AR	See 40 91 00	See 40 91 00	
	Discrete Input Module	AR	See 40 91 00	See 40 91 00	
	Discrete Output Module	AR	See 40 91 00	See 40 91 00	
	24V dc power supply	2		Phoenix Contact	Each power supply shall be suitable to supply all 24V power requirements.
	Diode Redundancy Module	1	Quint-Diode/12-24DC	Phoenix Contact	
TFEPSPLC	PROGRAMMABLE CONTROLLER (existing)		CQM1H-CPU51 (existing)	OMRON	Location: Trickling Filter Effluent Pump Station
	4 Point Isolated Analog Input Module	1	ADO42	OMRON	New module on existing PLC.
<p>Note 1: Where Allen-Bradley products are listed as the design was based on the first name manufacturer, equal substitutions are allowed.</p> <p>Note 2: AR = As Required. Provide quantity of I/O modules to accommodate all inputs and outputs shown in I/O list including spares.</p>					

CONTROL PANEL SCHEDULE											
Panel No.	Requirements	Mounting	NEMA	Dimensions			FDT	Space Heater	Serv. Lights, Outlets	Environment	SS
				H	W	D					
3096CCMPEP	Non-ventilated local control panel for local control monitoring, and control of equipment. Local control panel shall incorporate: <ol style="list-style-type: none"> 1. PLC 2. Wire terminations, power supplies, isolation relays, surge protection, and other components required to provide complete PICS. 3. Provide power distribution with control panel using circuit breakers and/or fused terminal blocks. 4. UPS Bypass switch and UPS located outside panel. 5. Provide panel mounted HMI. 	Freestanding	12	72	72	24	Yes	No	Yes	Inside, Air Conditioned	No
4481CCMBB	Non-ventilated local control panel for local control monitoring, and control of equipment. Local control panel shall incorporate: <ol style="list-style-type: none"> 1. PLC 2. Wire terminations, power supplies, isolation relays, surge protection, and other components required to provide complete PICS. 3. Provide power distribution with control panel using circuit breakers and/or fused terminal blocks. UPS Bypass switch and UPS located outside panel.	Freestanding	12	72	72	24	Yes	No	Yes	Inside, Air Conditioned	No

CONTROL PANEL SCHEDULE											
Panel No.	Requirements	Mounting	NEMA	Dimensions			FDT	Space Heater	Serv. Lights, Outlets	Environment	SS
				H	W	D					
3096NCPPEP	<p>Non-Ventilated 19" network rack cabinet. Cabinet shall enclose network equipment and shall have door access to front of equipment and a rear hinge to access back of network equipment. Network equipment enclosure shall incorporate.</p> <ol style="list-style-type: none"> 1. Ethernet Switch(es) 2. Fiber optic Patch Panel 3. Power strip for powering equipment. <p>Manufacturer and Model: Chatsworth; CUBE-iT (or equal)</p>	Wall mounted	N/A	24	24	24	No	No	No	Inside, Air Conditioned	No
4482NCPBB	<p>Non-Ventilated 19" network rack cabinet. Cabinet shall enclose network equipment and shall have door access to front of equipment and a rear hinge to access back of network equipment. Network equipment enclosure shall incorporate.</p> <ol style="list-style-type: none"> 1. Ethernet Switch(es) 2. Fiber optic Patch Panel 3. Power strip for powering equipment. <p>Manufacturer and Model: Chatsworth; CUBE-iT (or equal)</p>	Wall mounted	N/A	24	24	24	No	No	No	Inside, Air Conditioned	No

CONTROL PANEL SCHEDULE											
Panel No.	Requirements	Mounting	NEMA	Dimensions			FDT	Space Heater	Serv. Lights, Outlets	Environment	SS
				H	W	D					
2003NCPSPS	Non-Ventilated 19" network rack cabinet. Cabinet shall enclose network equipment and shall have door access to front of equipment and a rear hinge to access back of network equipment. Network equipment enclosure shall incorporate. 1. Ethernet Switch(es) 2. Fiber optic Patch Panel 3. Power strip for powering equipment. Manufacturer and Model: Chatsworth; CUBE-iT (or equal)	Wall mounted	N/A	24	24	24	No	No	No	Inside, Air Conditioned	No
Column Descriptions: FDT: Factory Demonstration test required. Dimensions: Approximate panel size requirements. SS: Stainless Steel.											

CH2M HILL LOOP STATUS REPORT—EXAMPLE FORMAT

Rev.06.05.92

Project Name: <i>Newport News WTP</i>						Project No. <i>WDC23456.C1</i>	
FUNCTIONAL REQUIREMENTS:							
<i>1. Measure, locally indicate, and transmit RAS flow to LP-10.</i>							
<i>2. At LP-10 indicate flow and provide flow control by modulation of FCV-10-2.</i>							
<i>3. Provide high RAS flow alarm on LP-10.</i>							
COMPONENT STATUS (Check and initial each item when complete)							
Tag Number	Delivered	Tag ID Checked	Installation	Termination Wiring	Termination Tubing	Calibration	
<i>FE/FIT-10-2</i>	<i>Jan-12-90 DWM</i>	<i>Jan-12-90 DWM</i>	<i>Feb-7-90 DWM</i>	<i>Mar-5-90 DWM</i>	<i>N.A.</i>	<i>May-6-90 VDA</i>	
<i>FIC-10-2</i>	<i>Jan-12-90 DWM</i>	<i>Jan-12-90 DWM</i>	<i>Mar-5-90 DWM</i>	<i>Apr-4-90 DWM</i>		<i>May-4-90 VDA</i>	
<i>FSH-10-2</i>	<i>Jan-12-90 DWM</i>	<i>Jan-12-90 DWM</i>	<i>Mar-5-90 DWM</i>	<i>Apr-4-90 DWM</i>		<i>May-7-90 VDA</i>	
<i>FAH-10-2</i>	<i>Jan-12-90 DWM</i>	<i>Jan-12-90 DWM</i>	<i>Mar-5-90 DWM</i>	<i>Apr-4-90 DWM</i>		<i>May-7-90 VDA</i>	
<i>FCV-10-2</i>	<i>Mar-2-90 DWM</i>	<i>Mar-2-90 DWM</i>	<i>Apr-20-90 DWM</i>	<i>Apr-30-90 DWM</i>		<i>May-16-90 VDA</i>	
REMARKS: None.							
Loop Ready for Operation			By: <i>D.W. Munzer</i>		Date: <i>May-18-90</i>		Loop No.: <i>10-2</i>

CH2M HILL INSTRUMENT CALIBRATION SHEET—EXAMPLE—ANALYZER/TRANSMITTER Rev.06.05.92

COMPONENT			MANUFACTURER				PROJECT					
Code: A7			Name: Leeds & Northrup				Number: WDC30715.B2					
Name: pH Element & Analyzer/Transmitter			Model: 12429-3-2-1-7		Serial #: 11553322		Name: UOSA AWT PHASE 3					
FUNCTIONS												
Indicate? Y Record? N	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? N			CONTROL? N					
	Chart:			Describe:			Action? direct / reverse Modes? P / I / D					
Transmit/ Convert? Y	Scale:	1-14	pH units				SWITCH? N					
	Input:	1-14	pH units				Unit Range: Differential: fixed/adjustable					
	Output:	4-20	mA dc				Reset? automatic / manual					
ANALOG CALIBRATIONS						DISCRETE CALIBRATIONS					Note No.	
REQUIRED			AS CALIBRATED			REQUIRED			AS CALIBRATED			
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.	
			Indicated	Output	Indicated	Output						(note rising or falling)
1.0	1.0	4.0	1.0	4.0	1.0	3.9	1.	N.A.		N.A.		
2.3	2.3	5.6	2.2	5.5	2.3	5.6	2.					1.
7.5	7.5	12.0	7.5	11.9	7.5	12.0	3.					
12.7	12.7	18.4	12.7	18.3	12.6	18.3	4.					
14.0	14.0	20.0	14.0	20.0	14.0	20.0	5.					
CONTROL MODE SETTINGS:			P: N.A.	I:	D:		6.					
#	NOTES:								Component Calibrated and Ready for Start-up			
	1. Need to recheck low pH calibration solutions.								By: J.D. Sewell			
									Date: Jun-6-92			
									Tag No.: AIT-12-6[pH]			

CH2M HILL

I&C VALVE ADJUSTMENT SHEET—EXAMPLE

Rev.06.05.92

PARTS	Project Name: <i>SFO SEWPCP</i>		Project Number: <i>SFO10145.G2</i>		
Body	Type: <i>Vee-Ball</i>		Mfr: <i>Fisher Controls</i>		
	Size: <i>4-inch</i>		Model: <i>1049763-2</i>		
	Line Connection: <i>159 # ANSI Flanges</i>		Serial #: <i>1003220</i>		
Operator	Type: <i>Pneumatic Diaphragm</i>		Mfr: <i>Fisher Controls</i>		
	Action: <i>Linear – Modulated</i>		Model: <i>4060D</i>		
	Travel: <i>3-inch</i>		Serial #: <i>2007330</i>		
Positioner	Input Signal: <i>3-15 psi</i>		Mfr: <i>Fisher Controls</i>		
	Action: <i>Direct - air to open</i>		Model: <i>20472T</i>		
	Cam: <i>Equal percentage</i>		Serial #: <i>102010</i>		
Pilot	Action:		Mfr:		
Solenoid	Rating: <i>None</i>		Model:	Serial #:	
I/P Converter	Input: <i>4-20 mA dc</i>		Mfr: <i>Taylor</i>		
	Output: <i>3-15 psi</i>		Model: <i>10-T-576-3</i>		
	Action: <i>Direct</i>		Serial #: <i>1057-330</i>		
Position Switch	Settings: <i>Closed / Open 5 deg, rising</i>		Mfr: <i>National Switch</i>		
	Contacts: <i>Close / Close</i>		Model: <i>1049-67-3</i>		
			Serial #: <i>156 &157</i>		
Power Supply	Type: <i>Pneumatic</i>		Air Set Mfr: <i>Air Products</i>		
	Potential: <i>40 psi</i>		Model: <i>3210D</i>		
			Serial #: <i>1107063</i>		
ADJUSTMENTS	Initial	Date	VERIFICATION	Initial	Date
Air Set	<i>JDS</i>	<i>Jun-06-92</i>	Valve Action	<i>JDS</i>	<i>Jun-03-92</i>
Positioner	<i>JDS</i>	<i>Jun-06-92</i>	Installation	<i>JDS</i>	<i>Jun-03-92</i>
Position Switches	<i>JDS</i>	<i>Jun-06-92</i>	Wire Connection	<i>JDS</i>	<i>Jun-04-92</i>
I/P Converter	<i>JDS</i>	<i>Jun-07-92</i>	Tube Connection	<i>JDS</i>	<i>Jun-04-92</i>
Actual Speed	<i>JDS</i>	<i>Jun-07-92</i>			
REMARKS: <i>Valve was initially installed backwards.</i>				Valve Ready for Start-up	
<i>Observed to be correctly installed May-25-92</i>				By: <i>J.D. Sewell</i>	
				Date: <i>Jun-07-92</i>	
				Tag No.: <i>FCV-10-2-1</i>	

CH2M HILL PERFORMANCE TEST SHEET - EXAMPLE

Rev.06.05.92

Project Name: <i>SFO SEWPCP Plant Expansion</i>			Project No.: <i>SFO12345.C1</i>
<p>Demonstration test(s): For each functional Requirement of the loop: (a) List and number the requirement. (b) Briefly describe the demonstration test. (c) Cite the results that will verify the required performance. (d) Provide space for signoff.</p>			
<i>1. MEASURE EFFLUENT FLOW</i>			
<i>1.a With no flow, water level over weir should be zero and</i>			
<i>FIT indicator should read zero.</i>			<i>Jun-20-92 BDG</i>
<i>2. FLOW INDICATION AND TRANSMISSION TO LP & CCS</i>			
<i>With flow, water level and FIT indicator should be related by expression</i>			
<i>$Q(\text{MGD}) = 429 * H^{**}(2/3)$ (<i>H</i> = height in inches of water over weir).</i>			
<i>Vary H and observe that following.</i>			
<i>2.a Reading of FIT indicator.</i>			<i>Jun-6-92 BDG</i>
<i>2.b Reading is transmitted to FI on LP-521-1</i>			<i>Jun-6-92 BDG</i>
<i>2.c Reading is transmitted and displayed to CCS.</i>			<i>Jun-6-92 BDG</i>
<i>H(measured)</i>	<i>0</i>	<i>5</i>	<i>10</i>
<i>Q(computed)</i>	<i>0</i>	<i>47.96</i>	<i>135.7</i>
<i>Q(FIT indicator)</i>	<i>0</i>	<i>48.1</i>	<i>137</i>
<i>Q(LI on LP-521-1)</i>	<i>0</i>	<i>48.2</i>	<i>138</i>
<i>Q(display by CCS)</i>	<i>0</i>	<i>48.1</i>	<i>136.2</i>
Forms/Sheets Verified	By	Date	Loop Accepted By Owner
Loop Status Report	<i>J.D. Sewell</i>	<i>May-18-92</i>	By: <i>J.D. Smith</i>
Instrument Calibration Sheet	<i>J.D. Sewell</i>	<i>May-18-92</i>	Date: <i>Jun-6-92</i>
I&C Valve Calibration Sheet	<i>N.A.</i>		
Performance Test	By	Date	
Performed	<i>J. Blow MPSSDC Co.</i>	<i>Jun-6-92</i>	
Witnessed	<i>B. DeGlanville</i>	<i>Jun-6-92</i>	Loop No.: <i>30-12</i>

Instrument List

Tag Number	Component Code	Component Title	Secondary Element	Options	P&ID	Installation Detail
3071PI	P4	PRESSURE GAUGE		RANGE: 0- 60 PSIG	080-I-501	4091-304A
3072LIT	L5	LEVEL ELEMENT AND TRANSMITTER - ULTRASONIC	3071LE	RANGE: 0- 30 FEET	080-I-501	4091-253 and 4091-382
3073LIT	L5	LEVEL ELEMENT AND TRANSMITTER - ULTRASONIC	3072LE	RANGE: 0- 30 FEET	080-I-501	4091-253 and 4091-382
3087PE	P15	PRESSURE SEAL, ANNULAR		SIZE: 1 INCH TYPE: OFF-LINE	080-I-501	4091-304D
3087PI	P4	PRESSURE GAUGE		RANGE: 0 - 15 PSIG	080-I-501	4091-304D
3088PE	P15	PRESSURE SEAL, ANNULAR		SIZE: 1 INCH TYPE: OFF-LINE	080-I-501	4091-304D
3088PI	P4	PRESSURE GAUGE		RANGE: 0 - 15 PSIG	080-I-501	4091-304D
3089PE	P15	PRESSURE SEAL, ANNULAR		SIZE: 1 INCH TYPE: OFF-LINE	080-I-501	4091-304D
3089PI	P4	PRESSURE GAUGE		RANGE: 0 - 15 PSIG	080-I-501	4091-304D
3109FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	3109FE	SIZE: 30 INCHES RANGE: 0 - 15 MGD STREAM: TFML LINER: HARD RUBBER TRANSMITTER: REMOTE	080-I-511	4091-219
3112PE	P15	PRESSURE SEAL, ANNULAR		SIZE: 1 INCH TYPE: OFF-LINE	080-I-501	4091-304D
3112PIT	P9	PRESSURE TRANSMITTER		RANGE: 0 - 15 PSIG	080-I-501	4091-304D
3217FLOWME	RELOCATE EXISTING METER	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	3217FE	SIZE: 6 INCHES RANGE: 0 - 700 GPM STREAM: SECONDARY SLUDGE PROVIDE KIT TO MAKE INTEGRAL TRANSMITTER TO A REMOTE TRANSMITTER.	080-I-511	4091-219

Instrument List

Tag Number	Component Code	Component Title	Secondary Element	Options	P&ID	Installation Detail
4403FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4403FE	SIZE: 16 INCHES RANGE: 0 - 15 MGD STREAM: SECONDARY INFLUENT LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-502	4091-219
4404FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4404FE	SIZE: 16 INCHES RANGE: 0 - 15 MGD STREAM: SECONDARY INFLUENT LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-502	4091-219
4405FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4405FE	SIZE: 16 INCHES RANGE: 0 - 15 MGD STREAM: SECONDARY INFLUENT LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-504	4091-219
4406FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4406FE	SIZE: 16 INCHES RANGE: 0 - 15 MGD STREAM: SECONDARY INFLUENT LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-504	4091-219

Instrument List

Tag Number	Component Code	Component Title	Secondary Element	Options	P&ID	Installation Detail
4407FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4407FE	SIZE: 16 INCHES RANGE: 0 - 15 MGD STREAM: SECONDARY INFLUENT LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-506	4091-219
4408FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4408FE	SIZE: 16 INCHES RANGE: 0 - 15 MGD STREAM: SECONDARY INFLUENT LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-506	4091-219
4409FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4409FE	RANGE: 0 TO 7500 SCFM LINE SIZE: 8 INCH INCLUDE FLOW CONDITIONER	080-I-502	4091-219
4410FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4410FE	RANGE: 0 TO 7500 SCFM LINE SIZE: 8 INCH INCLUDE FLOW CONDITIONER	080-I-504	4091-219
4411FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4411FE	RANGE: 0 TO 7500 SCFM LINE SIZE: 8 INCH INCLUDE FLOW CONDITIONER	080-I-506	4091-219
4412FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4412FE	RANGE: 0 TO 7500 SCFM LINE SIZE: 8 INCH INCLUDE FLOW CONDITIONER	080-I-503	4091-210

Instrument List

Tag Number	Component Code	Component Title	Secondary Element	Options	P&ID	Installation Detail
4413FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4413FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-503	4091-210
4414FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4414FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-503	4091-210
4415FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4415FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-503	4091-210
4416AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4416AE	RANGE: 0-10 PPM	080-I-502	4091-162G, 4091-386
4417AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4417AE1, 4417AE2	RANGE: 0-10 PPM	080-I-503	4091-162G, 4091-386
4418AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4418AE3, 4418AE4	RANGE: 0-10 PPM	080-I-503	4091-162G, 4091-386
4419AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4419AE	RANGE: 0-10 PPM	080-I-504	4091-162G
4420FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4420FE	SIZE: 18 INCHES RANGE: 0 - 14 MGD STREAM: RETURN ACTIVATED SLUDGE LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-504	4091-219

Instrument List

Tag Number	Component Code	Component Title	Secondary Element	Options	P&ID	Installation Detail
4436FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4436FE	SIZE: 18 INCHES RANGE: 0 - 15 MGD STREAM: RETURN ACTIVATED SLUDGE LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-502	4091-219
4437FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4437FE	RANGE: 0 TO 7500 SCFM LINE SIZE: 8 INCH INCLUDE FLOW CONDITIONER	080-I-505	4091-210
4438FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4438FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-505	4091-210
4442FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4442FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-505	4091-210
4443FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4443FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-505	4091-210
4444AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4444AE1, 4444AE2	RANGE: 0-10 PPM	080-I-505	4091-162G, 4091-386
4445AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4445AE3, 4445AE4	RANGE: 0-10 PPM	080-I-505	4091-162G, 4091-386

Instrument List

Tag Number	Component Code	Component Title	Secondary Element	Options	P&ID	Installation Detail
4446FIT	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	4446FE	SIZE: 18 INCHES RANGE: 0 - 15 GPM STREAM: RETURN ACTIVATED SLUDGE LINER: HARD RUBBER TRANSMITTER: INTEGRAL	080-I-506	4091-219
4447AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4447AE	RANGE: 0-10 PPM	080-I-506	4091-162G, 4091-386
4448FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4448FE	RANGE: 0 TO 7500 SCFM LINE SIZE: 8 INCH INCLUDE FLOW CONDITIONER	080-I-507	4091-210
4449FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4449FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-507	4091-210
4450FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4450FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-507	4091-210
4451FIT	F51	FLOW ELEMENT AND TRANSMITTER, THERMAL MASS FLOW	4451FE	RANGE: 0 TO 1500 SCFM LINE SIZE: 4 INCH INCLUDE FLOW CONDITIONER	080-I-507	4091-210
4452AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4452AE1, 4452AE2	RANGE: 0-10 PPM	080-I-507	4091-162G, 4091-386
4453AIT	A20	DISSOLVED OXYGEN ELEMENT AND TRANSMITTER, NONMEMBRANE LUMINESCENT (LDO)	4453AE3, 4453AE4	RANGE: 0-10 PPM	080-I-507	4091-162G, 4091-386

Instrument List

Tag Number	Component Code	Component Title	Secondary Element	Options	P&ID	Installation Detail
4454LT	L52	LEVEL ELEMENT/TRANSMITTER, SUBMERSIBLE, WASTEWATER, NONFOULING		RANGE: 0 TO 40 FEET	080-I-510	4091-265
4455LSH	L18	LEVEL SWITCH, NON-MERCURY		SETPOINT: 2441.5	080-I-510	4091-275F
4456LSL	L18	LEVEL SWITCH, NON-MERCURY		SETPOINT: 2434.83	080-I-510	4091-275F
4457AIT	A30	PHOSPHATE ANALYZER	4457AE	RANGE: .05 TO 10mg/L	080-I-510	
4479PIT	P9	PRESSURE TRANSMITTER		RANGE: 0 - 15 PSIG	080-I-510	4091-304A

4481CCMBB INPUT/OUTPUT LIST

Tag Number	PID	I/O	Description	Zero State/ Low Range	One State/ High Range	PLC Address	Rk	St	Pt	Address
4251CREM	080-I-512	DI	BLOWER 1 INLET VALVE REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4251CCLOSED	080-I-512	DI	BLOWER 1 INLET VALVE CLOSED STATUS	NOT CLOSED	CLOSED	4483PLCBB				TBD
4251COPEN	080-I-512	DI	BLOWER 1 INLET VALVE OPEN STATUS	NOT OPEN	OPEN	4483PLCBB				TBD
4251FAIL	080-I-512	DI	BLOWER 1 FAIL ALARM	NORMAL	FAIL	4483PLCBB				TBD
4251ON	080-I-512	DI	BLOWER 1 ON STATUS	OFF	ON	4483PLCBB				TBD
4251REM	080-I-512	DI	BLOWER 1 STATER REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4253CREM	080-I-512	DI	BLOWER 2 INLET VALVE REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4253CCLOSED	080-I-512	DI	BLOWER 2 INLET VALVE CLOSED STATUS	NOT CLOSED	CLOSED	4483PLCBB				TBD
4253COPEN	080-I-512	DI	BLOWER 2 INLET VALVE OPEN STATUS	NOT OPEN	OPEN	4483PLCBB				TBD
4253FAIL	080-I-512	DI	BLOWER 2 FAIL ALARM	NORMAL	FAIL	4483PLCBB				TBD
4253ON	080-I-512	DI	BLOWER 2 ON STATUS	OFF	ON	4483PLCBB				TBD
4253REM	080-I-512	DI	BLOWER 2 STATER REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4255CREM	080-I-512	DI	BLOWER 3 INLET VALVE REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4255CCLOSED	080-I-512	DI	BLOWER 3 INLET VALVE CLOSED STATUS	NOT CLOSED	CLOSED	4483PLCBB				TBD
4255COPEN	080-I-512	DI	BLOWER 3 INLET VALVE OPEN STATUS	NOT OPEN	OPEN	4483PLCBB				TBD
4255FAIL	080-I-512	DI	BLOWER 3 FAIL ALARM	NORMAL	FAIL	4483PLCBB				TBD
4255ON	080-I-512	DI	BLOWER 3 ON STATUS	OFF	ON	4483PLCBB				TBD
4255REM	080-I-512	DI	BLOWER 3 STATER REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4257CREM	080-I-512	DI	BLOWER 4 INLET VALVE REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4257CCLOSED	080-I-512	DI	BLOWER 4 INLET VALVE CLOSED STATUS	NOT CLOSED	CLOSED	4483PLCBB				TBD
4257COPEN	080-I-512	DI	BLOWER 4 INLET VALVE OPEN STATUS	NOT OPEN	OPEN	4483PLCBB				TBD
4257FAIL	080-I-512	DI	BLOWER 4 FAIL ALARM	NORMAL	FAIL	4483PLCBB				TBD
4257ON	080-I-512	DI	BLOWER 4 ON STATUS	OFF	ON	4483PLCBB				TBD
4257REM	080-I-512	DI	BLOWER 4 STATER REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4259CREM	080-I-512	DI	BLOWER 5 INLET VALVE REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
4259CCLOSED	080-I-512	DI	BLOWER 5 INLET VALVE CLOSED STATUS	NOT CLOSED	CLOSED	4483PLCBB				TBD
4259COPEN	080-I-512	DI	BLOWER 5 INLET VALVE OPEN STATUS	NOT OPEN	OPEN	4483PLCBB				TBD
4259FAIL	080-I-512	DI	BLOWER 5 FAIL ALARM	NORMAL	FAIL	4483PLCBB				TBD
4259ON	080-I-512	DI	BLOWER 5 ON STATUS	OFF	ON	4483PLCBB				TBD
4259REM	080-I-512	DI	BLOWER 5 STATER REMOTE STATUS	LOCAL	REMOTE	4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD

4481CCMBB INPUT/OUTPUT LIST

Tag Number	PID	I/O	Description	Zero State/ Low Range	One State/ High Range	PLC Address	Rk	St	Pt	Address
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD

4481CCMBB INPUT/OUTPUT LIST

Tag Number	PID	I/O	Description	Zero State/ Low Range	One State/ High Range	PLC Address	Rk	St	Pt	Address
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD

4481CCM BB INPUT/OUTPUT LIST

Tag Number	PID	I/O	Description	Zero State/ Low Range	One State/ High Range	PLC Address	Rk	St	Pt	Address
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DI	DISCRETE INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD

4481CCMBB INPUT/OUTPUT LIST

Tag Number	PID	I/O	Description	Zero State/ Low Range	One State/ High Range	PLC Address	Rk	St	Pt	Address
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DI	SPARE			4483PLCBB				TBD
		DI	SPARE			4483PLCBB				TBD
		DI	SPARE			4483PLCBB				TBD
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		DI	SPARE			4483PLCBB				TBD
		DI	SPARE			4483PLCBB				TBD
		DI	SPARE			4483PLCBB				TBD
		DI	SPARE			4483PLCBB				TBD
		DI	SPARE			4483PLCBB				TBD

4481CCMBB INPUT/OUTPUT LIST

Tag Number	PID	I/O	Description	Zero State/ Low Range	One State/ High Range	PLC Address	Rk	St	Pt	Address
		DI	SPARE			4483PLCBB				TBD
		DI	SPARE			4483PLCBB				TBD
4251AOPEN	080-I-512	DO	BLOWER 1DISCHARGE VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4251BOPEN	080-I-512	DO	BLOWER 1BLOWOFF VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4251RUN	080-I-512	DO	BLOWER 1 RUN COMMAND	STOP	RUN	4483PLCBB				TBD
4253AOPEN	080-I-512	DO	BLOWER 2DISCHARGE VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4253BOPEN	080-I-512	DO	BLOWER 2BLOWOFF VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4253RUN	080-I-512	DO	BLOWER 2 RUN COMMAND	STOP	RUN	4483PLCBB				TBD
4255AOPEN	080-I-512	DO	BLOWER 3DISCHARGE VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4255BOPEN	080-I-512	DO	BLOWER 3BLOWOFF VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4255RUN	080-I-512	DO	BLOWER 3 RUN COMMAND	STOP	RUN	4483PLCBB				TBD
4257AOPEN	080-I-512	DO	BLOWER 4DISCHARGE VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4257BOPEN	080-I-512	DO	BLOWER 4BLOWOFF VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4257RUN	080-I-512	DO	BLOWER 4 RUN COMMAND	STOP	RUN	4483PLCBB				TBD
4259AOPEN	080-I-512	DO	BLOWER 5DISCHARGE VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4259BOPEN	080-I-512	DO	BLOWER 5BLOWOFF VALVE OPEN COMMAND	CLOSE	OPEN	4483PLCBB				TBD
4259RUN	080-I-512	DO	BLOWER 5 RUN COMMAND	STOP	RUN	4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD

4481CCMBB INPUT/OUTPUT LIST

Tag Number	PID	I/O	Description	Zero State/ Low Range	One State/ High Range	PLC Address	Rk	St	Pt	Address
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	DO	DISCRETE OUTPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
		DO	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DO	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
		DO	SPARE			4483PLCBB				TBD
4479PRESS	080-I-512	AI	BLOWER ALP DISCHARGE HEADER PRESSURE SIGNAL	0 PSIG	30 PSIG	4483PLCBB				TBD
4251CPOS	080-I-512	AI	BLOWER 1 INLET VALVE POSITION	0% OPEN	100% OPEN	4483PLCBB				TBD
4251AMPS	080-I-512	AI	BLOWER 1 AMPS DRAW	0 AMPS	XXX AMPS	4483PLCBB				TBD
4251TEMP	080-I-512	AI	BLOWER 1 DISCHARGE AIR TEMP	0 F	XXX F	4483PLCBB				TBD
4253CPOS	080-I-512	AI	BLOWER 2 INLET VALVE POSITION	0% OPEN	100% OPEN	4483PLCBB				TBD
4253AMPS	080-I-512	AI	BLOWER 2 AMPS DRAW	0 AMPS	XXX AMPS	4483PLCBB				TBD
4253TEMP	080-I-512	AI	BLOWER 2 DISCHARGE AIR TEMP	0 F	XXX F	4483PLCBB				TBD
4255CPOS	080-I-512	AI	BLOWER 3 INLET VALVE POSITION	0% OPEN	100% OPEN	4483PLCBB				TBD
4255AMPS	080-I-512	AI	BLOWER 3 AMPS DRAW	0 AMPS	XXX AMPS	4483PLCBB				TBD
4255TEMP	080-I-512	AI	BLOWER 3 DISCHARGE AIR TEMP	0 F	XXX F	4483PLCBB				TBD
4257CPOS	080-I-512	AI	BLOWER 4 INLET VALVE POSITION	0% OPEN	100% OPEN	4483PLCBB				TBD
4257AMPS	080-I-512	AI	BLOWER 4 AMPS DRAW	0 AMPS	XXX AMPS	4483PLCBB				TBD
4257TEMP	080-I-512	AI	BLOWER 4 DISCHARGE AIR TEMP	0 F	XXX F	4483PLCBB				TBD
4259CPOS	080-I-512	AI	BLOWER 5 INLET VALVE POSITION	0% OPEN	100% OPEN	4483PLCBB				TBD
4259AMPS	080-I-512	AI	BLOWER 5 AMPS DRAW	0 AMPS	XXX AMPS	4483PLCBB				TBD
4259TEMP	080-I-512	AI	BLOWER 5 DISCHARGE AIR TEMP	0 F	XXX F	4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD

4481CCMBB INPUT/OUTPUT LIST

Tag Number	PID	I/O	Description	Zero State/ Low Range	One State/ High Range	PLC Address	Rk	St	Pt	Address
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
	080-I-512	AI	ANALOG INPUT FROM EXISTING CONTROL PANEL			4483PLCBB				TBD
		AI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		AI	SPARE FOR GROUP B PROJECT			4483PLCBB				TBD
		AI	SPARE			4483PLCBB				TBD
		AI	SPARE			4483PLCBB				TBD
		AI	SPARE			4483PLCBB				TBD
		AI	SPARE			4483PLCBB				TBD
		AI	SPARE			4483PLCBB				TBD
		AI	SPARE			4483PLCBB				TBD
		AI	SPARE			4483PLCBB				TBD

SECTION 40 91 00
INSTRUMENTATION AND CONTROL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

- A. This section gives general requirements for instrumentation and control components.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

PART 2 PRODUCTS

2.01 GENERAL

- A. Article Mechanical Systems Components covers requirements of mechanical PIC components that are not specifically referenced by Section 40 90 00, Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.
- B. Article Electrical Components covers requirements for electrical PIC components that are not specifically referenced by Section 40 90 00, Instrumentation and Control for Process Systems, Instrument Lists.
- C. All other Part 2 articles cover components that are referenced by Instrument Lists in Section 40 90 00, Instrumentation and Control for Process Systems, or by specific component numbers in other PIC subsections.

- D. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 MECHANICAL SYSTEMS COMPONENTS

A. ON/OFF Valves:

1. Type: Ball valve.
2. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
 - a. Whitey; Series 41 through Series 43.
 - b. Hoke; Flomite 7100 Series.

2.03 ELECTRICAL COMPONENTS

A. Terminal Blocks for Enclosures:

1. General:
 - a. Connection Type: Screw compression clamp.
 - b. Compression Clamp:
 - 1) Complies with DIN-VDE 0611.
 - 2) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
 - 3) Guides strands of wire into terminal.
 - c. Screws: Hardened steel, captive, and self-locking.
 - d. Current Bar: Copper or treated brass.
 - e. Insulation:
 - 1) Thermoplastic rated for minus 55 degrees C to plus 110 degrees C.
 - 2) Two funneled shaped inputs to facilitate wire entry.
 - f. Mounting:
 - 1) Standard DIN rail.
 - 2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
 - 3) End Stops: Minimum of one at each end of rail.

- g. Wire Preparation: Stripping only permitted.
 - h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
 - i. Marking System:
 - 1) Terminal number shown on both sides of terminal block.
 - 2) Allow use of preprinted and field marked tags.
 - 3) Terminal strip numbers shown on end stops.
 - 4) Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.
 - 5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.
2. Terminal Block, General Purpose:
- a. Rated Voltage: 600V ac.
 - b. Rated Current: 30 amp.
 - c. Wire Size: 24 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Gray body.
 - f. Spacing: 0.25 inch, maximum.
 - g. Test Sockets: One screw test socket 0.079-inch diameter.
 - h. Manufacturer and Product: Entrelec; Type M4/6.T.
3. Terminal Block, Ground:
- a. Wire Size: 24 AWG to 10 AWG.
 - b. Rated Wire Size: 10 AWG.
 - c. Color: Green and yellow body.
 - d. Spacing: 0.25 inch, maximum.
 - e. Grounding: Electrically grounded to mounting rail.
 - f. Manufacturer and Product: Entrelec; Type M4/6.P.
4. Terminal Block, Blade Disconnect Switch:
- a. Rated Voltage: 600V ac.
 - b. Rated Current: 10 amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Gray body, orange switch.
 - f. Spacing: 0.25 inch, maximum.
 - g. Manufacturer and Product: Entrelec; Type M4/6.SNT.
5. Terminal Block Diode:
- a. Rated Voltage: 24V dc.
 - b. Rated Current: 30 ma.
 - c. Wire Size: 16 AWG.
 - d. Manufacturer and Product: Phoenix Contact ST-IN.
6. Terminal Block, Fused, 24V dc:
- a. Rated Voltage: 600V dc.
 - b. Rated Current: 25 amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.

- e. Color: Gray body.
 - f. Fuse: 0.25 inch by 1.25 inches.
 - g. Indication: LED diode 24V dc.
 - h. Spacing: 0.512 inch, maximum.
 - i. Manufacturer and Product: Entelec; Type ML10/13.SFD.
7. Terminal Block, Fused, 120V ac:
- a. Rated Voltage: 600V ac.
 - b. Rated Current: 25 amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Gray body.
 - f. Fuse: 0.25 inch by 1.25 inches.
 - g. Indication: Neon lamp, 110V ac.
 - h. Leakage Current: 1.8 mA, maximum.
 - i. Spacing: 0.512 inch, maximum.
 - j. Manufacturer and Product: Entelec; Type ML10/13.SFL.
8. Terminal Block, Fused, 120V ac, High Current:
- a. Rated Voltage: 600V ac.
 - b. Rated Current: 35 amps.
 - c. Wire Size: 18 AWG to 8 AWG.
 - d. Rated Wire Size: 8 AWG.
 - e. Color: Gray.
 - f. Fuse: 13/32 inch by 1.5 inches.
 - g. Spacing: 0.95 inch, maximum.
9. Manufacturer and Product: Entelec; Type MB10/24.SF.
- B. Relays:
- 1. General:
 - a. Relay Mounting: Plug-in type socket.
 - b. Relay Enclosure: Furnish dust cover.
 - c. Socket Type: Screw terminal interface with wiring.
 - d. Socket Mounting: Rail.
 - e. Provide holddown clips.
 - 2. Signal Switching Relay:
 - a. Type: Dry circuit.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 5 amps at 28V dc or 120V ac.
 - d. Contact Material: Gold or silver.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 0.9 watt (dc), 1.2VA (ac).
 - g. Expected Mechanical Life: 10,000,000 operations.
 - h. Expected Electrical Life at Rated Load: 100,000 operations.
 - i. Indication Type: Neon or LED indicator lamp.
 - j. Seal Type: Hermetically sealed case.

- k. Manufacturer and Product: Potter and Brumfield; Series KH/KHA.
- 3. Control Circuit Switching Relay, Nonlatching:
 - a. Type: Compact general purpose plug-in.
 - b. Contact Arrangement: 3 Form C contacts.
 - c. Contact Rating: 10A at 28V dc or 120V ac, and 6.6A at 240V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
 - g. Expected Mechanical Life: 10,000,000 operations.
 - h. Expected Electrical Life at Rated Load: 100,000 operations.
 - i. Indication Type: Neon or LED indicator lamp.
 - j. Push-to-test button.
 - k. Manufacturer and Product: Potter and Brumfield; Series KUP.
- 4. Control Circuit Switching Relay, Latching:
 - a. Type: Dual coil mechanical latching relay.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 10A at 28V dc or 120V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
 - g. Expected Mechanical Life: 500,000 operations.
 - h. Expected Electrical Life at Rated Load: 50,000 operations.
 - i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.
- 5. Control Circuit Switching Relay, Time Delay:
 - a. Type: Adjustable time delay relay.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 10A at 30V dc or 277V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As noted or shown.
 - f. Operating Temperature: Minus 10 degrees C to 55 degrees C.
 - g. Repeatability: Plus or minus 2 percent.
 - h. Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent of range.
 - i. Time Delay Setpoint: As noted or shown.
 - j. Mode of Operation: As noted or shown.
 - k. Adjustment Type: Integral potentiometer with knob external to dust cover.
 - l. Manufacturer and Products: Potter and Brumfield; Series CB for 0.1-second to 100-minute delay time ranges, Series CK for 0.1-second to 120-second delay time ranges.

C. Surge Suppressors:

1. General:
 - a. Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
 - b. Response: 5 nanoseconds maximum.
 - c. Recovery: Automatic.
 - d. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
 - e. Enclosure Mounted: Encapsulated inflame retardant epoxy.
2. Suppressors on 120V ac Power Supply Connections:
 - a. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
 - b. First-Stage Clamping Voltage: 350 volts or less.
 - c. Second-Stage Clamping Voltage: 210 volts or less.
 - d. Power Supplies for Continuous Operation:
 - 1) Four-Wire Transmitter or Receiver: Minimum 5 amps at 130V ac.
 - 2) All Other Applications: Minimum 30 amps at 130V ac.
3. Manufacturers and Products:
 - a. 120V ac Lines: Emerson Edco HSP-121.

D. Power Supplies:

1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
 - a. Protect instruments from damage due to power supply failure.
 - b. Protect power supply from damage due to external failure.
4. Enclosures: NEMA 1.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
 - a. Type: Indicating.
 - b. Mount so fuses can be easily seen and replaced.

E. Intrinsic Safety Barriers:

1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
 - a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.

2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
 - a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.
- F. Uninterruptible Power Supply (UPS):
 1. General:
 - a. Function: Provides uninterrupted power for local control panel and communication panel.
 2. Features:
 - a. One grommetted cable connection for 3C 10 AWG SO cord for input power. Cord shall be 6 feet long with NEMA 5-20P.
 - b. One grommetted cable connection for 3C 10 AWG SO cord for output power. Cord shall be 6 feet long with NEMA 5-20R.
 - c. Rating: 7,000 VA.
 - d. Input: 208V, 2 phases, 1 Neutral.
 - e. Output: 208V, 2 phases, 1 Neutral.
 - f. Alarm Relay Dry Contact Output:
 - 1) Contact Rating: 120V ac, 2A.
 - 2) Provide external relays and enclosure if required to meet contact rating.
 3. Manufacturer and Model: Eaton/FerrUPS; FE7 (or equal).
- G. UPS Bypass Switch:
 1. General:
 - a. Function: Allows power for local control panel to bypass UPS when providing periodic maintenance.
 2. Features:
 - a. Three-position "Bypass-UPS-OFF" switch for bypassing UPS.
 - b. Two-position "ON-OFF" for turning AC power off to UPS.
 - c. Provide 4 conductor #8 AWG SO cord from bypass switch to UPS as required for UPS input power and UPS output power.
 3. Manufacturers and Products: Powerware.

2.04 I&C COMPONENTS

- A. A20 Dissolved Oxygen Element and Transmitter, Nonmembrane Luminescent (LDO):
 1. General:
 - a. Function: Continuous measurement of dissolved oxygen (DO) concentration of process fluid.
 - b. Type: Luminescent or fluorescence sensor.
 - c. Parts: Element (sensor), transmitter (analyzer), external power supply, interconnecting cable, mounting hardware, and ancillaries.

2. Performance:
 - a. Range: 0 to 20 ppm.
 - b. Sensor Accuracy:
 - 1) Measurement: plus or minus 0.2 percent of span.
 - 2) Temperature: plus or minus 0.2 degrees C.
 - c. Response Time: Less than 40 seconds to 90 percent of value upon step change.
3. Element:
 - a. Luminescent or fluorescent sensor.
 - b. Process Temperature Range: 32 degrees F to 122 degrees F.
 - c. Submersion Depth: 350 feet maximum.
 - d. Sensor Cable: Integral 33 feet of cable. Provide additional length as required.
 - e. Junction Box: Provide junction or termination box and extension cable as required.
 - f. Mounting: 1-1/2 UNF - 12 UNF thread.
4. Transmitter:
 - a. Sensor Inputs: Up to two DO sensor inputs.
 - b. Display:
 - 1) Graphic dot matrix LCD to display DO.
 - 2) Auxiliary Readout:
 - a) Temperature.
 - b) Diagnostic warnings.
 - c) Error messages.
 - d) Other information.
 - c. Ambient Conditions:
 - 1) Temperature minus 4 degrees F to plus 140 degrees F.
 - 2) Humidity: 0 to 95 percent, relative, noncondensing.
 - d. Signal Interface:
 - 1) Analog Output:
 - a) Two isolated 4 mA to 20 mA dc for load impedance up to 500 ohms.
 - b) Outputs configurable for DO or temperature.
 - 2) Relay Outputs:
 - a) Three SPST; 5 amps resistive, 115V ac/230V ac/30V dc.
 - b) Each relay assignable to either DO or temperature.
 - c) Function:
 - (1) Control: Settings for fail safe on/off, high/low phasing, setpoint, deadband, and on/off displays.
 - (2) Alarm: Settings for fail safe on/off, high alarm point, high alarm point deadband, low alarm point, low alarm point deadband, and on/off relays.

- e. Enclosure: NEMA 4X/IP65 polycarbonate/aluminum.
 - f. Mounting Hardware: Suitable to support panel, surface, horizontal pipe, and vertical pipe mounting.
 - g. Power Requirements: 120V ac, 60-Hz.
 - h. Stainless steel equipment tag.
5. Accessories:
- a. Unless otherwise noted, provide submersion mounting hardware and mounting bracket as required to perform appropriate installation.
 - b. Provide sun shield for transmitter display.
6. Manufacturer and Product:
- a. Hach; sc200 LDO Analysis System.
 - b. Or equal.
- B. A30 Phosphate Analyzer and Transmitter:
1. General:
- a. Function: Online measurement of phosphates in plant effluent.
 - b. Parts: Analyzer, transmitter, and filterprobe.
2. Performance:
- a. Range: .05 to 15 mg/L.
 - b. Sensor Accuracy:
 - 1) Measurement: 2 percent plus or minus 0.05 mg/L
 - 2) Temperature: plus or minus 0.2 degree C.
 - c. Response Time: Less than 40 seconds to 90 percent of value upon step change.
3. Analyzer:
- a. Housing: Lockable, weatherproof, wall mounted enclosure.
 - b. General: Analyzer shall come equipped with instrumentation, reagents and sampling pump suitable to sample process stream and analyze.
 - c. Process Temperature Range: 39 degrees F to 104 degrees F.
 - d. Submersion Depth: 3 meters maximum.
 - e. Sample hose: Heated 5 meter long hose.
 - f. Measuring interval: 5 to 60 min adjustable.
 - g. Mounting: Wall-mounted.
4. Transmitter:
- a. Sensor Inputs: Up to four inputs.
 - b. Display:
 - 1) Graphic dot matrix LCD to display Phosphate levels.
 - 2) Auxiliary Readout:
 - a) Diagnostic warnings.
 - b) Error messages.
 - c) Other information.

- c. Ambient Conditions:
 - 1) Temperature minus 4 degrees F to plus 131 degrees F.
 - 2) Humidity: 0 to 95 percent, relative, noncondensing.
- d. Signal Interface:
 - 1) Analog Output: 4 mA to 20 mA dc for load impedance up to 500 ohms.
 - 2) Relay Outputs:
 - a) Three SPST; 5 amps resistive, 115V ac/230V ac/30V dc.
 - b) Function:
 - (1) Alarm: Settings for failure, or high phosphate levels.
- e. Enclosure: IP65.
- f. Mounting Hardware: Suitable to support panel, surface, horizontal pipe, and vertical pipe mounting.
- g. Power Requirements: 120V ac, 60-Hz.
- h. Stainless steel equipment tag.
- 5. Filterprobe:
 - a. Shall filter out particles 20 um and larger out of the sample stream.
 - b. Provide continuous self-cleaning with air bubbles.
 - c. Provide 5 meter long heated hose. Hose shall be powered from transmitter or analyzer.
 - d. Maximum Dimensions: 14 by 14 by 14.
- 6. Accessories:
 - a. Provide sun shield for transmitter display.
 - b. Provide mounting plate for mounting both analyzer and transmitter together.
 - c. Provide 12-month supply of reagents and other consumables.
 - d. Provide all additional accessories required to provide a complete functioning system.
- 7. Manufacturer and Product:
 - a. Hach; PHOSPHAX sc, sc1000 transmitter, and Filterprobe sc
 - b. Or equal.

C. F4 Flow Element and Transmitter, Electromagnetic:

- 1. General:
 - a. Function: Measure, indicate, and transmit the flow of a conductive process liquid in a full pipe.
 - b. Type:
 - 1) Electromagnetic flowmeter, with operation based on Faraday's Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.

- 2) Full bore meter with magnetic field traversing entire flow-tube cross section.
- 3) Unacceptable are insert magmeters or multiple single point probes inserted into a spool piece.
- c. Parts: Flow element, transmitter, interconnecting cables, and mounting hardware. Other parts as noted.
2. Service:
 - a. Stream Fluid:
 - 1) As noted.
 - 2) Suitable for liquids with a minimum conductivity of 5 microS/cm and for demineralized water with a minimum conductivity of 20 microS/cm.
3. Operating Temperature:
 - a. Element:
 - 1) Ambient: Minus 5 to 140 degrees F, typical, unless otherwise noted.
 - 2) Process: Minus 5 to 140 degrees F, typical, unless otherwise noted.
 - b. Transmitter:
 - 1) Ambient: Minus 5 to 140 degrees F, typical, unless otherwise noted.
 - 2) Storage: 15 to 120 degrees F, typical, unless otherwise noted.
4. Performance:
 - a. Flow Range: As noted.
 - b. Accuracy: Plus or minus 0.5 percent of rate for all flows resulting from pipe velocities of 2 to 30 feet per second.
 - c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
5. Features:
 - a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
 - b. No obstructions to flow.
 - c. Very low pressure loss.
 - d. Measures bi-directional flow.
6. Process Connection:
 - a. Meter Size (diameter inches): As noted.
 - b. Connection Type: 150-pound ANSI raised-face flanges; AWWA C207, Table 2 Class D; or wafer style depending on meter size, unless otherwise noted.
 - c. Flange Material: Carbon steel, unless otherwise noted.
7. Power (Transmitter): 120V ac, 60-Hz, unless otherwise noted.
8. Element:
 - a. Meter Tube Material: Type 304 or Type 316 stainless steel, unless otherwise noted.

- b. Liner Material: Hard rubber, unless otherwise noted.
 - c. Liner Protectors: Covers (or grounding rings) on each end to protect liner during shipment.
 - d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
 - e. Electrode Material: Type 316 stainless steel or Hastelloy C.
 - f. Grounding Ring:
 - 1) Required, unless otherwise noted.
 - 2) Quantity: Two, unless otherwise noted.
 - 3) Material: Type 316 stainless steel, unless otherwise noted.
 - g. Enclosure: NEMA 4X, minimum, unless otherwise noted.
 - h. Submergence:
 - 1) Temporary: Unless otherwise noted.
 - 2) Continuous (up to 10 feet depth), NEMA 6P/IP68: If noted.
 - i. Hazardous Area Certification:
 - 1) Class 1, Division 2, Groups A, B, C, D: If noted.
 - 2) Class 1, Division 1, Groups A, B, C, D, and FM Approved: If noted.
 - 3) Class 1, Division 1, Groups C, D, and FM Approved: If noted.
9. Transmitter:
- a. Mounting: As shown.
 - b. Display: Required.
 - 1) Digital LCD display, indicating flow rate and total.
 - 2) Bi-directional Flow Display: Required, unless otherwise noted.
 - a) Forward and reverse flow rate.
 - b) Forward, reverse and net totalization.
 - c. Parameter Adjustments: By keypad or non-intrusive means.
 - d. Enclosure: NEMA 4X, minimum.
10. Signal Interface (at Transmitter):
- a. Analog Output:
 - 1) Isolated 4 mA to 20 mA dc for load impedance from 0 ohm to at least 500 ohms minimum for 24V dc supply.
 - 2) Supports Superimposed Digital HART protocol: If noted.
11. Cables:
- a. Types: As recommended by manufacturer.
 - b. Lengths: As required to accommodate device locations.
12. Built-in Diagnostic System:
- a. Features:
 - 1) Field programmable electronics.
 - 2) Self-diagnostics with troubleshooting codes.
 - 3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.

- 4) Initial flow tube calibration and subsequent calibration checks.
 13. Factory Calibration:
 - a. Factory calibrated with metering certified accuracy traceable NIST.
 - b. Factory flow calibration system must be certified by volume or weight certified calibration devices.
 - c. Factory flow calibration system shall be able to maintain calibration flow rate for at least 5 minutes for repeatability point checks.
 14. Factory Ready for Future In situ Verifications: If noted.
 - a. Original meter parameter values available from vendor by request.
 15. Manufacturers:
 - a. Siemens Sitrans F M: 5100W (size: 1/2 to 48 inches).
 - b. Endress & Hauser, Inc. Flow Measuring System:
 - 1) Promag 50/53H (size: 1/12 to 4 inches).
 - 2) Promag 50/53P (size: 1/2 to 24 inches).
 - 3) Promag 50/53W (size: 1 to 78 inches).
 - c. Emerson Process Management, Rosemount Division:
 - 1) Model 8705 (flanged) and Model 8711(wafer) flow tubes.
 - 2) Model 8712 (surface) and Model 8732 (integral) transmitters.
 - d. Krohne [includes IFC 020K/IFC 090K (integral) or IFC 020F/IFC 090F (remote) signal converter].
 - 1) Aqua Flux Flowmeter (size: 3/8 to 120 inches).
 - 2) EnviroMag, IFS 4000 Flowmeter (size: 2 to 60 inches).
 - 3) IFS 1000 EcoFlux Flowmeter (size: 1/10 to 8 inches).
- D. F51 Flow Element and Transmitter, Thermal Mass Flow:
1. General:
 - a. Function: Directly measure, indicate, and transmit mass flow of gas in pipe.
 - b. Type: Insertion type, thermal dispersion detection probe using platinum resistance temperature detectors (RTD).
 - c. Parts: Elements, transmitter, flow conditioner, and interconnecting cable.
 2. Performance:
 - a. Process Gas: Low pressure air.
 - b. Range for Air at 70 Degrees F and 14.7 psia:
 - 1) As noted, within the following:
 - a) 0.25 to 1,600 standard fps.
 - b) 0.25 to 200 actual fps.
 - c. Calibrated Span: As noted.

- d. Accuracy:
 - 1) Flow: Plus or minus 1 percent of reading plus 0.5 percent full scale.
 - 2) Temperature: Plus or minus 2 degrees F.
 - e. Repeatability:
 - 1) Flow: Plus or minus 0.5 percent of reading.
 - 2) Temperature: Plus or minus 1 degree F.
 - f. Temperature, Operating:
 - 1) Flow Element: Minus 50 degrees F to plus 350 degrees F, unless otherwise noted.
 - 2) Transmitter Housing: 0 degree F to plus 150 degrees F.
 - g. Pressure, Operating, Flow Element: Up to 50 psig, unless otherwise noted.
3. Flow Element:
- a. Features:
 - 1) Insertion Length: As noted or manufacturer's recommendation.
 - 2) Wetted Surfaces Materials: Type 316 stainless steel with nickel braze, unless otherwise noted.
 - b. Process Connection:
 - 1) Line Size: As noted or shown.
 - 2) Connection Type: Retractable sensor with graphite-packed gland with 1-1/4-inch MNPT, unless otherwise noted.
 - 3) Connection Material: Type 316 stainless steel, unless otherwise noted.
 - c. Sensor Enclosure:
 - 1) Type: Aluminum, NEMA 4X.
4. Transmitter:
- a. Features:
 - 1) Integral to instrument.
 - 2) LCD digital display, scalable to flow rate.
 - b. Nonvolatile memory.
 - c. Signal Interface:
 - 1) Outputs:
 - a) Analog: Two isolated 4 mA to 20 mA dc for maximum 600 ohm load, unless otherwise noted.
 - d. Power:
 - 1) Selectable: 115V ac.
 - e. Electrical Connection: 1 1/4-inch FNPT.
 - f. Transmitter Enclosure:
 - 1) Type: Aluminum NEMA 4X, unless otherwise noted.
 - 2) Mounting: Integral to sensor.
 - g. Single factory calibration, unless otherwise noted.

5. Cables:
 - a. Length: As required.
 - b. Cable Jacket: PVC rated for 220 degrees F, unless otherwise noted.
 6. Flow Conditioner:
 - a. Function: Reduces flow stream irregularities with low pressure drop across the conditioner.
 - b. Type: Inline pipe spool that includes meter connection.
 - c. Line Size: As shown.
 - d. Material: Type 316 stainless steel schedule 40 pipe.
 - e. Connections: ANSI 150# flange.
 - f. Length: Seven pipe diameters maximum.
 - g. Flow meter connection: 1-inch FNPT.
 7. Manufacturer and Product: Fluid Components International; Model ST50.
- E. L5 Level Element and Transmitter, Ultrasonic:
1. General:
 - a. Function: Continuous, non-contacting level measurement.
 - b. Type: Ultrasonic.
 - c. Parts: Element, transmitter, interconnecting cable, and accessories as noted.
 2. Service:
 - a. Application: If and as noted.
 - b. Vapor Space Pressure: Atmospheric, unless otherwise noted.
 - c. Operating Temperature Range:
 - 1) Element: Minus 4 degrees F to plus 149 degrees F.
 - 2) Transmitter: Minus 4 degrees F to 113 degrees F.
 3. Performance:
 - a. Range: As noted.
 - b. Zero Reference: As noted.
 - c. Accuracy: Plus or minus 0.25 percent of maximum range or 6 mm, whichever is greater.
 - d. Resolution: 0.1 percent of range or 2 mm, whichever is greater.
 - e. Blanking Distance: Sensor dependent, typically 1 foot.
 4. Element:
 - a. NEMA 6P waterproof.
 - b. Housing: PVDF, unless otherwise noted.
 - 1) Other materials subject to Engineer approval.
 - c. Facing: None, unless otherwise noted.
 - d. Integral Flange: If noted.
 - 1) Face: PTFE, unless otherwise noted.
 - 2) Size: As noted.

- e. Process Connection:
 - 1) 1-inch NPT, unless otherwise noted.
 - 2) Top mounted.
- f. Electrically Hazardous Rating:
 - 1) Class I, Div 1, Groups A, B, C, and D: If noted.
 - 2) Class II, Div 1, Groups E, F, and G: If noted.
 - 3) Other Ratings: As noted.
- g. Beam Angle: 12 degrees or less.
- h. Integral temperature compensation.
- 5. Transmitter:
 - a. Display.
 - b. Integral keypad or nonintrusive external programming.
 - c. Enclosure: NEMA 4X polycarbonate, unless otherwise noted.
 - d. Power Supply: 115 volts, 50/60-Hz, unless otherwise noted.
 - e. Isolated Analog Output:
 - 1) One Minimum: 4 mA to 20 mA dc for load impedance of 0 to 750 ohms.
 - f. Discrete Outputs:
 - 1) Minimum, two relay (SPDT) rated for 2 amps continuous at 230V ac.
 - 2) Assignable and as noted.
- 6. Interconnecting Cable: Weatherproof, UV protected, length as required, and type as recommended by manufacturer.
- 7. Accessories:
 - a. Submergence Shield.
 - b. Remote Programming Software: If noted.
 - 1) Allows remote programming via computer and echo traces for troubleshooting.
 - 2) One per lot of units furnished.
 - c. If no integral keypad, furnish one handheld programmer per lot of units furnished.
- 8. Manufacturers and Products:
 - a. Siemens; SITRANS L, Model HydroRanger 200 and Sensor.
 - b. Endress & Hauser; Model FMU90 and Sensor.
- F. L18 Level Switch, Non-Mercury:
 - 1. General:
 - a. Function: Actuate contact at preset liquid level.
 - b. Type:
 - 1) Direct-acting, stainless steel float with enclosed, encapsulated switch and integral cable.
 - 2) Mercury free.
 - 2. Service (Liquid): Wastewater, unless otherwise noted.

3. Performance:
 - a. Setpoint: As noted.
 - b. Differential: 8 inches maximum.
 - c. Temperature: 32 degrees F (nonfreezing) to 160 degrees F.
4. Features:
 - a. Entire Assembly: Watertight and impact-resistant.
 - b. Float:
 - 1) Material and Size: 5.5-inch diameter polymer-coated, Type 316 stainless steel float.
 - 2) Buoyancy: 2 pounds.
 - c. Cable:
 - 1) Length as noted or as necessary per mounting requirements.
 - 2) Plastic-jacketed cable, oil-resistant, and suitable for continuous service.
 - d. Mounting: Anchor, unless otherwise noted.
 - 1) Pipe Mounting: If noted.
 - a) Cable clamp, suitable for connection to 1-inch pipe.
 - b) Pipe-to-wall bracket, suitable for connection to 1-inch pipe.
 - 2) Anchor Mounting Kit: If noted.
 - a) 15-pound vinyl-coated cast-iron anchor.
 - b) Type 316 stainless steel chain.
 - c) Stainless steel cable clips.
5. Signal Interface:
 - a. Switch Type: Magnetic reed.
 - b. Switch Contacts:
 - 1) Isolated, rated at least 0.8 amp continuous at 120V ac.
 - 2) Contact Type: Either NO or NC, as required by application or as noted; or SPDT (NO and NC).
6. Accessories: As noted.
7. Manufacturers and Products:
 - a. Siemens Water Technologies; Model 9G-EF Direct Acting Float Switch (B100).
 - b. Contegra; Model FS90.

G. L52 Level Element/Transmitter, Submersible, Wastewater, Nonfouling:

1. General:
 - a. Function: Measure and transmit signal proportional to level.
 - b. Type:
 - 1) Totally submersible pressure sensor (loop powered).
 - 2) Nonfouling.
 - 3) Suitable for wastewater, slurries, and viscous fluids.
 - c. Parts: Sensor, interconnecting cable, other parts as noted.

2. Service:
 - a. Fluid: Wastewater, unless otherwise noted.
3. Performance:
 - a. Process Range:
 - 1) As noted.
 - 2) Provide fixed factory range such that noted process range is between 40 and 80 percent of fixed factory range.
 - b. Accuracy: 0.25 percent of full scale.
 - c. Temperature, Operating: Minus 4 degrees F to plus 140 degrees F.
 - d. Overpressure:
 - 1) Proof: At least 1.5 times full scale.
 - 2) Burst: At least 2.0 times full scale.
4. Features:
 - a. Sensor:
 - 1) Silicon pressure-sensing element.
 - 2) Type 316 stainless steel pressure module assembly.
 - 3) Other Wetted Materials: Teflon.
 - 4) NEMA 6/IP 68 rating (submersible).
 - 5) Temperature compensation.
 - 6) Sensing Area: 2.75-inch diameter.
 - 7) Integral diaphragm protector.
 - 8) Dimensions, Nominal:
 - a) Pressure-Sensing Assembly: 1-inch diameter.
 - b) Sensing Area Assembly: 4-inch diameter.
 - c) Length (without integral lightning protector): 8 inches.
 - 9) Nominal Weight: 3.5 pounds.
 - 10) Loop powered, 9V dc to 30V dc.
 - b. Interconnecting Cable:
 - 1) Length: As required.
 - 2) Polyurethane sheathed, unless otherwise noted.
 - 3) Kevlar strain relief cord.
 - 4) Integral vent tube.
 - c. Sensor Termination Enclosure: Required, unless otherwise noted.
 - 1) Enclosure: NEMA 4X.
 - 2) Houses such noted items as desiccant vent, filter, microfilter.
 - d. Accessories:
 - 1) Desiccant Module: Required, unless otherwise noted.
 - 2) Spare Desiccant Modules:
 - a) Quantity: Three.
 - 3) Cable Hanger, Kellems Type Grip: Required, unless otherwise noted.

- 4) Lightning Protection:
 - a) Internal (protects against water lightning strike):
Required, unless otherwise noted.
 - b) External (protects 4 mA to 20 mA dc output):
Required, unless otherwise noted.
5. Signal Interface: 4 mA to 20 mA dc output, for load impedance of 0 to 750 ohms, minimum for 24V dc supply without load adjustment.
6. Electrical Connection: 1/2-inch, 14 NPT male conduit fitting with molded cable seal, unless otherwise noted.
7. Certification(s):
 - a. Class I, Div 1, Groups A, B, C, and D.
 - b. Class II, Div 1, Groups E, F, and G.
 - c. Class III, Div 1.
8. Manufacturer and Model:
 - a. Esterline; KPSI Model 750.
 - b. Endress+Hauser; Deltapilot FMB52.

H. P4 Pressure Gauge:

1. General:
 - a. Function: Local pressure indication.
 - b. Type: Bourdon tube element.
2. Performance:
 - a. Scale Range: As noted.
 - b. Accuracy: Plus or minus 0.50 percent of full scale.
3. Features:
 - a. Dial: 4-1/2-inch diameter.
 - b. Pointer Vibration Reduction: Required, unless otherwise noted.
Use the following method.
 - 1) Liquid filled gauge front, unless otherwise noted.
 - a) Glycerine fill, unless otherwise noted.
 - c. Case Material: Black thermoplastic, unless otherwise noted.
 - d. Materials of Wetted Parts (including element, socket/process connection, throttling device (if specified) and secondary components):
 - 1) Stainless steel, unless otherwise noted.
 - e. Pointer: Adjustable by removing ring and window.
 - f. Window: Glass or acrylic, unless otherwise noted.
 - g. Threaded reinforced polypropylene front ring.
 - h. Case Type: Solid front with blow-out back.
4. Process Connection:
 - a. Mounting: Lower stem, unless otherwise noted.
 - b. Size: 1/2-inch MNPT, unless otherwise noted.

- 5. Accessories:
 - a. Throttling Device: Required, unless otherwise noted.
 - 1) Type suitable for the intended service.
 - 2) Install in gauge socket bore.
- 6. Manufacturers and Products:
 - a. Ashcroft; Duragauge Model 1259/Model, 1279/Model, 1279 PLUS!
 - b. Ametek U.S. Gauge; Solfrunt Model 19XX/1981 Advantatge.
 - c. WIKA, Type 2XX.34.

I. P8 Pressure Switch, Fixed Deadband:

- 1. General:
 - a. Function: Monitor pressure.
 - b. Type: Diaphragm actuated switch.
- 2. Performance:
 - a. Setpoint:
 - 1) As noted.
 - 2) Repeatability: Plus or minus 1 percent.
 - b. Range: Noted setpoint shall fall between 20 percent and 80 percent of range.
 - c. Overpressure Proof Pressure: At least 400 percent of rated maximum static pressure.
 - d. Operating Temperature Range:
 - 1) Dependent on actuator seal materials.
 - 2) For Buna-N seal, 0 degrees F to 150 degrees F.
- 3. Features:
 - a. Actuator Seal: Buna-N, unless otherwise noted.
 - b. Differential (deadband): Fixed.
 - c. Reset: Automatic, unless otherwise noted.
 - d. Mounting: Surface, unless otherwise noted.
- 4. Process Connection:
 - a. 1/4-inch NPT female connections, unless otherwise noted.
 - b. Materials: Nickel-plated brass, unless otherwise noted.
- 5. Enclosure: NEMA 4X.
- 6. Signal Interface:
 - a. Contact Type:
 - 1) SPDT, unless otherwise noted.
 - 2) Rated for 10 amps minimum at 120V ac.
 - b. Hermetically Sealed Switch: If noted.
- 7. Manufacturers and Products:
 - a. Ashcroft; Type 400, B Series.
 - b. United Electric; 400 Series.

J. P9 Pressure Transmitter:

1. General:
 - a. Function: Measure pressure and transmit signal proportional to pressure.
 - b. Type:
 - 1) Electronic variable capacitance or silicon strain gauge.
 - 2) Two-wire transmitter; "smart electronics".
 - c. Parts: Transmitter and accessories.
2. Performance:
 - a. Range: As noted.
 - 1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
 - b. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
 - c. Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.
 - d. Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.
 - e. Humidity: 0 to 100 percent relative humidity.
 - f. Hazardous Location Certifications: If and as noted.
3. Features:
 - a. Type: Gauge pressure, unless otherwise noted.
 - b. Adjustable damping.
 - c. LCD indicator, unless otherwise noted.
 - 1) Display in either percent or engineering units, field configurable.
 - d. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
 - 1) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
 - e. Wetted O-Rings: Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise noted.
 - f. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
 - g. Fill Fluid: Silicone, unless otherwise noted.
4. Process Connections:
 - a. Line Size: 1/2 inch.
 - b. Connection Type: FNPT.
 - c. Direct/remote Diaphragm Seal: If and as noted.
5. Signal Interface: 4 to 20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.
 - a. Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.

6. Enclosure:
 - a. Type: NEMA 4X.
 - b. Materials: Coated aluminum, unless otherwise noted.
 - c. Mounting bracket, unless otherwise noted.
 - 1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
 7. Accessories: Two-valve (isolate and vent) Stainless Steel Manifold: If noted.
 8. Manufacturers and Products:
 - a. Gauge Pressure Units:
 - 1) Rosemount; Model 3051 TG.
 - 2) Foxboro; Model IGP20.
 - 3) Endress+Hauser.
- K. P15 Pressure Seal, Annular:
1. General:
 - a. Function:
 - 1) Sense pressure in a process line and transfer to pressure monitoring device.
 - 2) Protect attached pressure monitoring device from sludge or slurry.
 - b. Type: Annular fluid-filled device that senses pressure through flexible sleeve around full pipe circumference.
 2. Performance:
 - a. Operating Conditions: Suitable for line pressures up to pipe flange rating.
 3. Features:
 - a. Construction:
 - 1) In-line, 8 Inches and Smaller: Full-faced thru-bolted with outside diameter same as mating flanges, unless otherwise noted.
 - 2) In-line, 10 Inches and Larger: Wafer style.
 - 3) Offline: Threaded, unless otherwise noted.
 - b. Materials:
 - 1) Body: Carbon steel, unless otherwise noted.
 - 2) Flanges (where applicable): Carbon steel, unless otherwise noted.
 - 3) Flexible Sleeve: Buna-N, unless otherwise noted.
 - 4) Fill Fluid: Ethylene glycol/water or propylene glycol, unless otherwise noted.
 - c. Factory Filled System:
 - 1) Filled and assembled with pressure monitoring device(s).
 - 2) Coordinate attached pressure monitoring device(s) with system integrator. Seal vendor's standard pressure

- monitoring device(s) only acceptable if it meets specification of the related pressure monitoring device.
4. Process Connections:
 - a. Mounting: In-line or offline, as noted or shown.
 - b. Pipe Size:
 - 1) In-line: As noted or shown.
 - 2) Offline: 2 inches, unless otherwise noted.
 - c. Connections:
 - 1) In-line, Full-faced through-bolted: ASME B16.5, 150-pound flanges.
 - 2) In-line, Wafer style: Compatible with Classes 150/300 flange drilling.
 - 3) Offline: Female NPT Threaded, unless otherwise noted.
 5. Manufacturers and Products:
 - a. Red Valve Company; Series 40, Series 42/742, Series 48.
 - b. Dover/OPW Engineered Systems; Iso-Ring.
- L. Y50 Programmable Logic Controller System:
1. PLC Manufacturer; Model:
 - a. Allen-Bradley; Control Logix L7 Series.
 - b. Modicon; Quantum Unity Pro 140-CPU-651.
 - c. Siemens; Simatic S7-300 or S7-400 series.
 2. Provide all additional accessories or devices for a complete functional system.
 - a. Firmware upgrades.
 - b. Software.
 - c. Communication modules.
 - d. I/O modules.
 - e. Circuiting.
 - f. Enclosure.
 - g. Relays.
 - h. Converters.
 - i. Communication protocol converters.
 - j. Communication integration work.
 3. Control Processor:
 - a. Ethernet connections: 64 minimum.
 4. Power Supply Module:
 - a. Input Voltage: 120V ac.
 - b. Power supply shall be suitable for system plus 20 percent additional I/O.
 5. PLC I/O Chassis:
 - a. Slots: As required for I/O.
 6. Ethernet Communication Module:
 - a. Receive and Transmit Speed: 10/100 Mbs.

7. Digital Input Module:
 - a. Voltage Rating: 120V ac.
 - b. Individually isolated inputs.
 - c. Maximum of 16 inputs per module.
8. Digital Output Module:
 - a. Relay type (dry contact).
 - b. Ratings: 2A, 120V.
 - c. Maximum of 16 outputs per module.
9. Analog Input Module:
 - a. All channels shall be individually isolated.
 - b. Channels Per Module: 8, maximum.
 - c. Type: 4 mA to 20 mA current.
10. Analog Output Module:
 - a. Channels: 8, maximum.
 - b. Type: Current, 4 mA to 20 mA.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 40 95 80
FIBER OPTIC COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. Electronic Components, Assemblies, and Materials Association (ECA): 310-E, Cabinets, Racks, Panels, and Associated Equipment.
 2. Institute of Electrical and Electronic Engineers, Inc. (IEEE): 802.3, Telecommunications and Information Exchange Between Systems—Local and Metropolitan Networks.
 3. Insulated Cable Engineers Association (ICEA):
 - a. S-83-596, Optical Fiber Premises Distribution Cable.
 - b. S-87-640, Optical Fiber Outside Plant Communications Cable.
 - c. S-104-696, Indoor-Outdoor Optical Fiber Cable.
 4. International Organization for Standardization (ISO): 9001, Quality Management Systems—Requirements.
 5. International Telecommunication Union (ITU): T G.652, Characteristics of a Single-mode Optical Fibre and Cable.
 6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 7. QuEST Forum (QF): TL 9000, Quality Management Systems.
 8. Rural Development Utilities Programs (RDUP):
 - a. 7 CFR 1755.902, Minimum Performance Specification for Fiber Optic Cables.
 - b. 7 CFR 1755.903, Fiber Optic Service Entrance Cables.
 9. Telecommunications Industry Association (TIA):
 - a. 526-7, OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
 - b. 526-14, OFSTP-14 Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
 - c. 568-C.1, Commercial Building Telecommunications Cabling Standards.
 - d. 568-C.3, Optical Fiber Cabling Components Standard.
 - e. 598, Optical Fiber Cable Color Coding.
 - f. 606, Administration Standard for Commercial Telecommunications Infrastructure.
 10. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
 - a. 455-78, FOTP-78 - IEC 60793-1-40 Optical Fibres Part 1-40: Measurement Methods and Test Procedures – Attenuation.

- b. 455-133, FOTP-133 IEC-60793-1-22 Optical Fibres Part 1-22: Measurement Methods and Test Procedures Length Measurement.
 - c. 492AAAA, Detail Specification for 62.5-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
 - d. 492AAAB, Detail Specification for 50-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
 - e. 492AAAC, Detail Specification for 850-nm Laser-Optimized, 50-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
 - f. 492CAAA, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers.
 - g. 492CAAB, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak.
 - h. 604-2, FOCIS-2 Fiber Optic Connector Intermateability Standard, Type ST.
 - i. 604-3, FOCIS-3 Fiber Optic Connector Intermateability Standard, Type SC and SC-APC.
 - j. 604-12, FOCIS-12 Fiber Optic Connector Intermateability Standard, Type MT-RJ.
 - k. 942, Telecommunications Infrastructure Standard for Data Centers.
 - l. TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems-Contains Color.
11. Underwriter Laboratories (UL): 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.02 DEFINITIONS

- A. ATM: Asynchronous Transfer Mode.
- B. AUI: Attachment Unit Interface.
- C. dB: Decibel.
- D. DNI: Desktop Network Interface.
- E. EMB: Effective Modal Bandwidth.
- F. ETL: Electrical Test Laboratories.
- G. FDDI: Fiber Distributed Data Interface.
- H. FIM: Facilities Information Management.

- I. Flux Budget: Difference between transmitter output power and receiver input power required for signal discrimination when both are expressed in dBm.
- J. FOCS: Fiber Optic Communication System.
- K. FOIRL: Fiber Optic Inter Repeater Link.
- L. Fusion Splice: Connecting ends of two fibers together by aligning fiber ends and applying electric arc to fuse ends together.
- M. Hybrid Cable: Cable containing more than one type of fiber.
- N. LAN: Local Area Network.
- O. LIMS: Laboratory Information Management System.
- P. m: Micrometer.
- Q. Mbps: Megabits per Second.
- R. Mechanical Splice: Connecting ends of two fibers together by means other than fusion.
- S. Megahertz (MHz): One million cycles per second.
- T. MHz: Megahertz.
- U. micro: $\times 10^{-6}$.
- V. Micron: Micrometer or one millionth meter.
- W. MIS: Management Information System.
- X. n, nano: $\times 10^{-9}$.
- Y. N: Newton.
- Z. nm: Nanometer—unit of measure equal to one billionth meter.
- AA. OFL: Over-filled Launch.
- BB. OFN: Nonconductive Optical Fiber Cable.
- CC. OFNP: Nonconductive Optical Fiber Plenum Cable.
- DD. OFNR: Nonconductive Optical Fiber Riser Cable.
- EE. OLTS: Optical Loss Test Sets.

- FF. OTDR: Optical Time Domain Reflectometer.
- GG. OVD: Outside Vapor Deposit.
- HH. PIC: Process Instrumentation and Control.
- II. Plenum: Air return path of central air handling system, such as open space above suspended ceiling.
- JJ. RLM: Restricted Mode Launch.
- KK. ROL: Reverse Oscillation Lay.
- LL. SPC: Super Physical Contact.
- MM. UPC: Ultra Physical Contact.
- NN. UPS: Uninterruptible Power Supply.
- OO. V ac: Volts Alternating Current.
- PP. WAN: Wide Area Network.

1.03 SYSTEM DESCRIPTION

- A. Function of FOCS is to transmit digital data between network nodes over fiber optic media. Requirements listed identify minimum acceptable system performance.
- B. Provide a FOCS based on referenced standards for use in the following local and wide area networks:
 - 1. SCADA.
 - 2. Security.
 - 3. HVAC.
 - 4. Power Monitoring.
 - 5. VOIP.
 - 6. Fire Alarm.
- C. Network(s) will be used by SCADA, Security, Power monitoring, HVAC, Fire Alarm, and Phone to distribute data and coordinate Owner’s operations.
- D. Major Work Items:
 - 1. Contractor shall submit, provide, install, label, and test all network cabling. Refer to Drawings. Network block diagrams illustrate the fiber cabling, CAT6 cabling, and network connections to the multiple

- systems. The electrical site plans and duct banks schedules show the physical location of fiber optic cable installations.
2. Contractor shall label and test all fiber optic cables, and components installed. Testing shall confirm that complete fiber path is within requirements.
 3. Coordinate testing schedule with PICS contractor. All fiber testing must be done and approved prior to Functional Test 2. See Section 40 90 00, Instrumentation and Control for Process Systems.
 4. Coordinate with Owner's System Integrator to determine fiber optic patch cord connections.

E. Work Not Included in this Contract:

1. Supply and configuration of Ethernet Switches: All Ethernet switches will be supplied by the Owner. Configuration of all Ethernet switches shall be provided by Owner's System Integrator.

1.04 SUBMITTALS

A. Action Submittals:

1. Site Layout Diagram Showing:
 - a. Access holes, with identification.
 - b. Belowgrade conduit routings between access holes and buildings, with conduit counts and identification.
 - c. Belowgrade innerduct routings through conduits, with innerduct counts and identification.
 - d. Cable routings through innerducts and to patch panels, fiber centers, or network nodes, with cable and node identification.
2. Cable Schedule Showing:
 - a. Cable identification.
 - b. Fiber counts for each cable and identification of used fiber pairs.
 - c. Cable length and attenuation, with two connector pairs and no splice(s), based on TIA 568-C.3, Annex H.
3. Component Data:
 - a. Manufacturer and model number.
 - b. General data and description.
 - c. Engineering specifications and data sheet.
 - d. Scaled drawings and mounting arrangements.

B. Informational Submittals:

1. Manufacturer's statement that installer is certified to perform installation Work.

2. Subcontractor Qualifications:
 - a. FOCS Subcontractor: Minimum of 5 years' experience providing, integrating, installing, and commissioning of similar systems.
 - 1) Statement of Experience: List of at least three fiber optic data communications systems comparable to system specified which have been furnished and placed into operation. For each system, provide following information:
 - a) Owner's name, address, telephone number, and name of current operations supervisor or other contact.
 - b) Description of system hardware configuration, including major equipment items, number of nodes, and communication standards implemented.
 - b. FOCS Subcontractor's Site Representative: Minimum of 5 years' experience installing similar systems.
 - c. Qualification of Personnel:
 - 1) Resumes identifying management and technical qualifications of supervisory, local service representative, and key personnel.
 - 2) Qualification data of firm and persons to demonstrate capabilities and experience in the following areas:
 - a) Fiber optic cable handling and placement techniques.
 - b) Fiber optic splicing and installation of connections.
 - c) Attenuation testing procedures.
 - d. Owner acceptance of FOCS Subcontractor does not exempt FOCS Subcontractor or Contractor from meeting Contract Document requirements nor does it give prior acceptance of subsystems, equipment, materials, or services.
 - e. Testing and acceptance plan, 30 days prior to beginning of testing.
 - f. Fiber test results. Documentation covering fiber facility testing, not later than 2 days after testing, showing:
 - 1) Manufacturer's tag of attenuation per fiber as recorded from OTDR reading before shipment.
 - 2) Attenuation of each fiber upon delivery to Site.
 - 3) Attenuation of each fiber plus connector after installation as recorded from OTDR with tracing.
 - 4) Flux Budget calculations with comparison to measured attenuation for each run verifying adequate optical signal strength.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
4. Manufacturer's suggested installation practice.
5. Operation and Maintenance Data: As specified in Section 01 76 00, Operating and Maintenance Information.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Optical Fiber Cable:

1. Outside, Underground/Submerged: Minus 20 degrees C to 40 degrees C.
2. Outside, Overhead: Minus 40 degrees C to 80 degrees C.
3. Outside, Aboveground in Conduit: Minus 40 degrees C to 80 degrees C.
4. Inside: 0 degree C to 40 degrees C.

B. Equipment:

1. Outside, Aboveground: Minus 40 degrees C to 80 degrees C.
2. Control Rooms, Equipment Rooms, and Telecommunications Closets: 30 percent to 55 percent relative humidity, 10 degrees C to 35 degrees C.
3. Other Interior Areas: 0 percent to 100 percent relative humidity, 5 degrees C to 35 degrees C.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Cable:
 - a. ISO 9001 or QF TL 9000 registered, whichever applies to material.
 - b. Minimum of 20 years in manufacturing optical fiber cable in order to demonstrate reliable field performance.
2. Housing: ISO 9001 and QF TL 9000 registered.
3. Connector:
 - a. ISO 9001 or QF TL 9000 registered.
 - b. Minimum 10-year history of manufacturing and supporting connector technology that does not require epoxy or polishing in field.
4. Jumper Cable: ISO 9001 and QF TL 9000 registered.

B. Installer Qualifications:

1. Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.
2. Certified by fiber cable manufacturer.
3. Lead cabling installation personnel shall have BICSI Installer 2 or Technician certification.

- C. Tester Qualifications: Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.
 - 1. Technician: Successfully attended training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof. Certificate may have been issued by the following organizations or an equivalent organization:
 - a. Manufacturer of fiber optic cable and fiber optic connectors.
 - b. Manufacturer of test equipment used for field certification.
 - c. Other independent training organizations acceptable to Owner.
 - d. Lead cabling installation personnel shall have BICSI Installer 2 or Technician certification.
- D. Provide connectors/coupling, splicing enclosures, mounting hardware, and miscellaneous accessories for fibers by same manufacturer.

1.07 SPECIAL GUARANTEE

- A. Provide manufacturer’s extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of Work specified in this specification section found defective during a period of 2 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in General Conditions.

1.08 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts:

<u>Item</u>	<u>Quantity</u>
3-foot patch cords	24

- B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 FIBER OPTIC CABLE

- A. Single-Mode: 9/125-micron Class IVa dispersion-unshifted optical fibers for use in the backbone distribution subsystem shall meet or exceed requirements of TIA 568-C.3, including the following specifications:

1. Chromatic Dispersion:
 - a. Zero-Dispersion Wavelength: Between 1,302 nm and 1,322 nm.
 - b. Maximum value of dispersion slope at zero dispersion wavelength shall be no greater than 0.093 ps per km-nm².
2. Mode Field Diameter: Nominal 8.7 microns to 10 microns, with a tolerance of plus or minus 0.5 micron at 1,300 nm.
3. Maximum Attenuation:
 - a. Outside and Indoor-Outdoor Optical Fiber Cable:
 - 1) 0.5 dB per km at 1,310 nm.
 - 2) 0.5 dB per km at 1,550 nm.
 - b. Inside Optical Fiber Cable:
 - 1) 1 dB per km at 1,310 nm.
 - 2) 1 dB per km at 1,550 nm.
4. Cutoff Wavelength of Cabled Fiber: Less than 1,260 nm.
5. TIA 492 CAAB (OS2) low water peak and complies with ITU T G.652 (A to D).
6. Distance Capacity per IEEE 802.3:
 - a. 1 Gbit Ethernet, 1,300 nm Laser Minimum Distance: 5000 m.
 - b. 10 Gbit Ethernet: 10 km at 850 nm and 40 km at 1,310 nm.

B. Innerduct:

1. Function: Installs into conduit system provided by others, to provide smooth, low-friction path through conduit, with only one cable per path to facilitate changing individual cables.
2. Features:
 - a. Size and Count, in 5-inch Conduit: As shown on Drawings.
 - b. Type: Annular, corrugated innerduct.
 - c. Material: HDPE.
 - d. Color Code: Orange.
 - e. Strength: Minimum 600-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.
 - f. Lubrication: Prelubricated.
3. Manufacturers:
 - a. Endocor.
 - b. Dura-Line.

2.02 HOUSINGS

A. Fiber Optic Patch Panel (FOPP):

1. Rack mountable connector housing.
2. Mountable in ECA 310-E compatible 465-mm or 592-mm rack.

3. Available in several sizes, including 1U, 2U, 3U, and 4U: One ECA rack space or panel height (denoted as U) is defined as being 44.45 mm in height.
4. In accordance with design requirements of TIA 568-C.3 and polymer compounds flammability requirements of UL 94.
5. Manufactured using 16-gauge aluminum or equivalent for structural integrity.
6. Finished with wrinkled black powder coat for durability.
7. Provide black installation fasteners.
8. Six adapter panels shall mount in each termination housing. Each adapter panel shall terminate six LC terminations (12 fibers).
9. Available sizes with their corresponding fiber capacities are noted below:

Termination Housing Sizes and Fiber Capacities				
Unit Size	Panel Capacity	Fiber Capacity with 6f Panels	Fiber Capacity with 12f Panels	Fiber Capacity with 24f Panels
2U	6	36	72	144

2.03 CONNECTORS

A. General:

1. Comply with TIA/EIA 604-2, TIA/EIA 604-3, TIA/EIA 604-12, and TIA 568-C.3.
2. LC connectors.
3. Pull Strength: 0.2 N minimum.
4. Durability: Sustain minimum 500 mating cycles without violating other requirements.
 - a. Ferrules: Free-floating low loss ceramic.
 - b. Polarizing key on duplex connector systems.
5. Attenuation:
 - a. In accordance with TIA 568-C.3.
 - b. Maximum of 0.75 dB per connector pair.
6. Manufacturer: AMP.

2.04 PATCHCORDS

A. General:

1. In accordance with TIA 568-C.3.
2. Function: Connect fiber centers to network nodes, such as computer workstations.
3. Fiber Characteristics: In accordance with requirements for fiber optic cable.

4. Cable Configuration:
 - a. Individual tight-buffer thermoplastic, fibers single or multimode, to match fibers being jumpered on.
 - b. Protected with Kevlar strength members and enclosed in thermoplastic jacket.
5. Length: Standard, to meet requirements shown, plus minimum 3 meters at workstations.
6. Connectors:
 - a. As required by Article Connectors.
 - b. On-axial Pull Strength: 33 N.
 - c. Normal-to-Axial Pull Strength: 22 N.
7. Cable Rating: OFNR or OFNP.
8. Color: Per standards or as indicated.
9. Measured for insertion loss with the following values for each connector: Typical of 0.3 dB and maximum of 0.5 dB (LC typical of 0.1 dB and maximum of 0.3 dB).

2.05 ETHERNET SWITCH

- A. Ethernet switches will be provided by the Owner.

2.06 CONDUIT

- A. In accordance with Section 26 05 33, Raceway and Boxes.

2.07 ACCESSORIES

- A. Hardware: Provide cable clamps, strain reliefs, blocking and grommet kits, closures, and fan outs for complete installation.
- B. Labels: Provide labels for all cables.

PART 3 EXECUTION

3.01 PREPARATION

- A. Conduit:
 1. Ensure installed conduit system conforms to fiber optic system requirements, including:
 - a. Conduits and Innerducts: Size and number.
 - b. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables and innerducts may be installed without exceeding manufacturer's limitations.
 - c. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.

2. Expansion Plugs: Seal conduit to stop ingress of water and grit with fabricated expansion plugs.
3. Ensure duct bank, conduit, and other confined routing is free and clear of debris before cable placement.

B. Innerduct:

1. In accordance with manufacturer's recommendations.
2. Install quantity of innerduct tubing for all fiber optic conduits as shown on Drawings.
3. Install no more than one innerduct of each color in single conduit. Color coding ends of innerduct with paint is acceptable.
4. Terminate innerducts in conduit with fabricated termination kits.
5. Identify innerducts at both ends by methods such as color-coding or waterproof tags wired through innerduct wall.
6. Sealing:
 - a. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.
 - b. Innerduct to Conduit: Seal gaps between innerducts and conduit with sealing compound such as 3M Ductseal.
 - c. Empty Innerducts: After installation, seal with fabricated expansion plugs to stop ingress of water and grit. Remove plugs as required to install cables.

3.02 INSTALLATION

A. Fiber Optic Cable:

1. Specified fiber counts, routing, origination, and terminating points are indicated on Drawings.
2. Installation by manufacturer's certified installer.
3. Install cables in accordance with manufacturer's requirements.
4. Install cable directly from shipping reels. Ensure that cable is:
 - a. Not dented, nicked, or kinked.
 - b. Not subjected to pull stress greater than manufacturer's specification.
 - c. Not bent to a radius below manufacturer's minimum bend radius.
 - d. Not subjected to treatment that may damage fiber strands during installation.
5. Cables per Conduit or Innerduct: One cable maximum. If calculation indicates cable will attenuate signals more than 8 dB, reroute may be allowed if approved by Engineer.
6. Splices: Install fiber optic cables in unspliced lengths from fiber centers to switches or hubs.

7. Connector: Insertion loss on multimode connections exceeding 0.5 dB and 0.4 dB on single-mode connections not permitted.
 8. Identification:
 - a. Identify cable on both ends, in access holes, and pull points.
 - b. Identification shall include locations of termination.
 9. Arrange cable, equipment, and hardware to provide neat appearance and accessibility for servicing.
 10. Access Holes:
 - a. Provide supports for cables in access and handholes at minimum 600 mm centers along sides.
 - b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.
- B. Fiber Center, Fiber Distribution Frame, Housing, Panel: Install securely in field panels or enclosures as shown on Drawings.
- C. Cable Terminations:
1. In accordance with TIA 568-C.3.
 2. Fan out fiber cable to allow direct connectorization of connectors.
 - a. Sleeve over individual fibers with transparent furcation tubes.
 - b. At point of convergence of furcation tubes, provide strain relief with metal or high density plastic fan-out collar.
 3. Break-out Kits:
 - a. Terminate cables using manufacturer-supplied break-out kits.
 - b. Terminate in accordance with manufacturer's recommendations.
 4. Slack:
 - a. Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
 5. Connectors:
 - a. Terminate 100 percent of fibers in each cable to specified connector.
 - b. Connect into fiber management system.
- D. Ethernet Fiber-to-Copper Transceivers:
1. Install transceivers in accordance with manufacturer's instructions.
 2. Location: Install transceivers securely in field panels, close to network nodes and fiber centers.
 3. Power: Energize each transceiver from its field panel's UPS, if applicable.
 4. Connections:
 - a. Connect transceiver to fiber optics and network node.
 - b. Lace fiber optics neatly in place, routed through wireways.
- E. Conduit: Install in accordance with Section 26 05 33, Raceway and Boxes.

3.03 LABELING CONVENTIONS

- A. Label in accordance with circuit labeling requirements in Section 26 05 05, Conductors. At a minimum, every fiber cable, and fiber shall include unique number with label on both ends. All labels shall be included on all fiber network connections drawings. Labelling of every cable shall be per requirements of TIA/EIA 606-A labeling standards.

3.04 FIELD QUALITY CONTROL

A. General:

1. Advise Engineer at least 48 hours in advance of each test. Engineer shall have option to witness and participate actively in tests.
2. In accordance with Section 01 75 00, Testing, Equipment Startup, and Commissioning.
3. Provide equipment, instrumentation, supplies, and skilled staff necessary to perform testing.
4. Cables, patch panels, and associated components shall be fully assembled and labeled prior to field testing.
5. Testing performed on incomplete systems shall be redone on completion of the Work.
6. Document Test Results: Confirm each cable has at least specified number of fibers that meet standards, in accordance with As-Built Fiber Optic Cable Installation form included as Supplement to this section.
7. Confirm quantities and sizes of conduit and innerduct, in accordance with As-Built Conduit/Innerduct Installation form included as Supplement to this section.
8. Test all fiber cables inclusive of connectors and network components.

B. Test Equipment:

1. Field test instruments shall have latest software and firmware installed.
2. Optical Fiber Cable Testers:
 - a. Field test instrument shall be within calibration period recommended by manufacturer.
 - b. Optical Loss Test Set (OLTS):
 - 1) Single-mode Optical Fiber Light Source:
 - a) Provide dual laser light sources with central wavelengths of 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
 - b) Output Power: Minus 10 dBm, minimum.
 - c) Manufacturer: Fluke Networks.
 - 2) Power Meter:
 - a) Provide 850 nm, 1,300/1,310 nm, and 1,550 nm wavelength test capability.

- b) Power Measurement Uncertainty: Plus or minus 0.25 dB.
 - c) Store reference power measurement.
 - d) Save at least 100 results in internal memory.
 - e) PC interface (serial or USB).
 - f) Manufacturer: Fluke Networks.
 - 3) Optional Length Measurement: Capable of measuring optical length of fiber using time-of-flight techniques.
 3. Optical Time Domain Reflectometer (OTDR):
 - a. Bright, color transmissive LCD display with backlight.
 - b. Rechargeable for 8 hours of normal operation.
 - c. Weight with battery and module of not more than 4.5 pounds and volume of not more 200 cubic inches.
 - d. Internal nonvolatile memory and removable memory device with at least 16 MB capacity for results storage.
 - e. Serial and USB ports to transfer data to PC.
 - f. Single-mode OTDR:
 - 1) Wavelengths: 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
 - 2) Event Dead Zone: 2 meters maximum at 1,310 nm and 2 meters maximum at 1,550 nm.
 - 3) Attenuation Dead Zone: 15 meters maximum at 1,310 nm and 15 meters maximum at 1,550 nm.
 - 4) Distance Range: Minimum 10,000 meters.
 - 5) Dynamic Range: Minimum 10 dB at 1,310 nm and 1,550 nm.
 4. Fiber Microscope:
 - a. Magnification: 250X or 400X for end-face inspection.
 - b. Manufacturer: Fluke Networks.
 5. Integrated OLTS, OTDR, and Fiber Microscope:
 - a. Test equipment that combines into one instrument such as OLTS, OTDR, and fiber microscope may be used.
 - b. Manufacturer: Fluke Networks.
- C. Conduit Test:
 1. Test and seal spare conduits.
 2. Conduit and Innerduct Testing:
 - a. Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.
 - b. If conduit is restricted over full length, advise Engineer.
 3. Documentation: Confirm conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.

D. Cable Testing:

1. Test procedures and field test instruments shall comply with applicable requirements of:
 - a. LIA Z136.2.
 - b. TIA/EIA 455-78.
 - c. TIA/EAI 455-133.
 - d. TIA 526-7.
 - e. TIA 526-14.
 - f. TIA 568-C.1.
 - g. TIA 568-C.3.
 - h. TIA TSB 140.
2. Test attenuation and polarity of installed cable plant with OLTS and installed condition of cabling system and its components with OTDR.
3. Verify condition of fiber end face.
4. Perform on each cabling link (connector to connector).
5. Perform on each cabling channel (equipment to equipment).
6. Do not include active devices or passive devices within link or channel other than cable, connectors, and splices. For example, link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
7. Document Tests:
 - a. OLTS dual wavelength attenuation measurements for single-mode and multimode links and channels.
 - b. OTDR traces and event tables for single-mode and multimode links and channels.

E. Fiber Testing Parameters: Each cabling link shall be in compliance with the following test limits:

1. Optical Loss Testing:
 - a. Backbone (single-mode and multimode) Link:
 - 1) Calculate link attenuation by the formulas specified in TIA 568-C.1.
 - 2) Values for Attenuation Coefficient (dB/km) are listed in the table below:

Attenuation Coefficient				
Type of Optical Fiber	Wavelength (nm)	Attenuation Coefficient (dB/km)	Wavelength (nm)	Attenuation Coefficient (dB/km)
Single-mode (Inside plant)	1310	1.0	1550	1.0

2. OTDR Testing:
 - a. Reflective Events: Maximum 0.75 dB.
 - b. Nonreflective Events: Maximum 0.3 dB.
 3. Magnified Endface Inspection:
 - a. Visually inspect fiber connections for end-face quality.
 - b. Scratched, pitted, or dirty connectors shall be diagnosed and corrected.
- F. Diagnosis and Correction:
1. Installed cabling links and channels shall be field tested and pass test requirements and analysis as described herein.
 2. Link or channel that fails these requirements shall be diagnosed and corrected.
 3. Document corrective action and follow with new test to prove corrected link or channel meets performance requirements.
 4. Provide final and passing result of tests for links and channels.
- G. Acceptance: Acceptance of test results shall be given in writing after Project is tested and completed in accordance with Contract Documents and satisfaction of Owner.
- H. Fiber Optic Cable Functional Test Execution:
1. Optical Fiber Cable Testing:
 - a. Tests performed that use laser or LED in test set shall be carried out with safety precautions in accordance with LIA Z136.2.
 - b. Link and channel test results from OLTS and OTDR shall be recorded in test instrument upon completion of each test for subsequent uploading to a PC in which administrative documentation may be generated.
 - 1) Record end-face images in memory of test instrument for subsequent uploading to a PC and reporting.
 - c. Perform Testing:
 - 1) On each cabling segment (connector to connector).
 - 2) On each cabling channel (equipment to equipment).
 - 3) Using high-quality test cords of same fiber type as cabling under test.
 - a) Test cords for OLTS testing shall be between 1 meter and 5 meters in length.
 - b) Test cords for OTDR testing shall be approximately 100 meter for launch cable and at least 25 meters for receive cable.

2. Optical Loss Testing (OLTS):
 - a. Backbone Link:
 - 1) Test single-mode at 1,310 nm and 1,550 nm in accordance with TIA 526-7, Method A.1, One Reference Jumper or equivalent method.
 - 2) Perform tests in both directions.
3. OTDR Testing:
 - a. Test backbone links at appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
 - 1) Single-mode: 1,310 nm and 1,550 nm.
 - b. Test each fiber link and channel in one direction.
 - c. Install launch cable between OTDR and first link connection.
 - d. Install receive cable after last link connection.
4. Length Measurement:
 - a. Record length of each fiber.
 - b. Measure optical length using OLTS or OTDR.
5. Test Results Documentation:
 - a. Test results saved within field-test instrument shall be transferred into Windows-based database utility that allows for maintenance, inspection, and archiving of test records. These test records shall be uploaded to the PC unaltered. For example, “as saved in the field-test instrument.” The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
 - b. Available for inspection by Owner or Owner’s representative during installation period. Submit within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling.
 - c. Circuit IDs reported by test instrument shall match specified label identification.
 - d. Provide in electronic database for each tested optical fiber with the following information:
 - 1) Identification of Site.
 - 2) Name of test limit selected to execute stored test results.
 - 3) Name of personnel performing test.
 - 4) Date and time test results were saved in memory of tester.
 - 5) Manufacturer, model, and serial number of field test instrument.
 - 6) Version of test software and version of test limit database held within test instrument.
 - 7) Fiber identification label.
 - 8) Length for Each Optical Fiber: Optionally the index of refraction used for length calculation when using a length capable OLTS.

- 9) Test results to include OLTS attenuation link and channel measurements at appropriate wavelength and margin; difference between measured attenuation and test limit value.
 - 10) Test results to include OTDR link and channel traces, and event tables at appropriate wavelength.
 - 11) Length for each optical fiber as calculated by the OTDR.
 - 12) Overall pass/fail evaluation of link-under-test for OLTS and OTDR measurements.
6. Communication Functional Test: Upon completion of cable and component installation and testing, and upon acceptance of cable and component testing submittals, the entire Network Communication System shall be tested as a functional system.
- a. Confirm proper Ethernet communication can occur over each fiber path. Test shall include Ethernet switches as well as cables.
 - b. Document each test and method of testing.

I. Drawings:

1. Record Copy: Provide at end of Project on CD-ROM.
 - a. CAD format and include notations reflecting as-built conditions of additions and variations from Drawings provided, such as to cable path and termination point.
 - b. CAD drawings are to incorporate test data imported from test instruments.
2. As-built Drawings:
 - a. Include, but not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts, and frame installation details.
 - b. Include field changes made up to construction completion:
 - 1) Field directed changes to pull schedule.
 - 2) Field directed changes to cross connect and patching schedule.
 - 3) Horizontal cable routing changes.
 - 4) Backbone cable routing or location changes.
 - 5) Associated detail drawings.

END OF SECTION

**SECTION 43 22 56.01
SUBMERSIBLE MIXERS**

EQUIPMENT AND COMPONENT NUMBER(S)

<u>Equipment Number</u>	<u>Equipment Name</u>
4460AB1MX1	AB1 Selector Zone Mixer 1
4461AB1MX2	AB1 Selector Zone Mixer 2
4462AB1MX1	AB1 FAZ Mixer 1
4472AB2MX1	AB2 Selector Zone Mixer 1
4473AB2MX2	AB2 Selector Zone Mixer 2
4474AB2MX1	AB2 FAZ Mixer 1
4478AB3MX1	AB3 Selector Zone Mixer 1
4467AB3MX2	AB3 Selector Zone Mixer 2
4468AB3MX1	AB3 FAZ Mixer 1

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

- A. General Requirements: See Division 01, General Requirements, which contains information and requirements that apply to the Work specified herein and are mandatory for this Project.

1.02 WORK OF THIS SECTION

- A. The Work of this section includes providing the submersible mixers and all appurtenant work for Aeration Basins 1, 2 and 3. There are three submersible mixers in each Aeration Basin located in the Selector Zone, and Flexible Aerobic Zone (FAZ).
- B. Unit Responsibility: The Work requires that the aeration basin submersible mixers, complete with all accessories and appurtenances (including, but not necessarily limited to, electric motors, mast assemblies, and components), be the end product of one responsible system manufacturer or responsible system supplier. Unless otherwise indicated, the Contractor shall obtain each system from the responsible supplier of the equipment, which supplier shall furnish all components and accessories of the system to enhance compatibility, ease of operation and maintenance, and as necessary to place the equipment in operation in conformance with the specified performance, features and

functions without altering or modifying the Contractor's responsibilities under the Contract Documents. The Contractor is responsible to the Owner for providing the equipment systems as specified herein.

1.03 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Iron and Steel Institute (AISI).
2. American National Standards Institute (ANSI).
3. American Standard Association (ASA).
4. American Water Works Association (AWWA).
5. Anti-friction Bearing Manufacturer's Assoc. (AFBMA).
6. ASTM International (ASTM).
7. International Standards Organization (ISO).
8. National Electric Code (NEC).
9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Agency (NFPA).

1.04 SUBMITTALS

A. Action Submittals:

1. Drawings showing complete dimensional data.
2. Complete literature on the mechanical mixers.
3. Calculations verifying that provided mixer meets mixing criteria for the application.
4. See Section 26 20 00, Low-Voltage AC Induction Motors, for motor submittal requirements.
5. Anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.
6. Wiring diagrams for leak sensors, temperature sensors, and motor protection relays if required.

B. Informational Submittals:

1. Factory Functional Test Reports.
2. Manufacturer's Certification of Compliance that the factory finish system is identical to the requirements specified herein.
3. Special shipping, storage and protection, handling instructions.
4. Manufacturer's printed installation instructions.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
6. Suggested spare parts list to maintain the equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance.

7. List of special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
8. Operation and Maintenance Data: As specified in Section 01 76 00, Operating and Maintenance Information.
9. Anchorage and bracing calculations as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.

1.05 EXTRA MATERIALS

- A. Furnish for each mixer:
 1. Gear reducer bearings.
 2. Set of O-rings.
 3. Complete set of seals.

1.06 QUALITY ASSURANCE

- A. Provide a written guarantee that the submersible mixer will provide uniform mixing as required. If in the opinion of the Engineer, the unit fails to uniformly blend the fluid, replace the unit with a suitable mixer at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Where a manufacturer's standard equipment name and/or model number is listed, the equipment system shall be provided as modified to conform to the performance, functions, features, and materials of construction as specified herein.
- B. Materials, equipment, components, and accessories specified in this section shall be products of:
 1. Landia, Inc., Cary, NC.
 2. Or equal.

2.02 GENERAL REQUIREMENTS

- A. All wetted parts shall be Type 316 or Type 304 stainless steel with the exception of the motor housing and gear box. Wetted parts are defined as any parts extending below the top of aeration basin walls.
- B. Service Factors: Service factors shall be applied in the selection and design of components where so indicated in individual sections. When not indicated

there, minimum service factors shall be 1.25, except for gears and gear drives as specified herein.

- C. Safety Devices: The completed Work shall include all necessary permanent safety devices, such as machinery guards, emergency stops and similar items required by OSHA, and other federal, state, and local health and safety regulations.
- D. Flanges and Pipe Threads: Flanges on equipment shall comply with ANSI B16.1, Class 125; or ANSI B16.5, Class 150, unless otherwise indicated. Threaded flanges and fittings shall have standard taper pipe threads complying with ANSI/ASME B1.20.1.
- E. Bearings:
 - 1. Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).
 - 2. All drive bearings shall be of the antifriction type, ball or roller bearings. The output shaft shall be supported by tapered roller bearings.
 - 3. Except where otherwise indicated, bearings of process equipment shall have minimum AFBMA B-10 lives of 100,000 hours when operating at full motor nameplate horsepower at design speed.
 - 4. Material selections shall comply with AGMA values and the manufacturer's recommendations.
- F. Gears and Gear Drives:
 - 1. Except as otherwise indicated, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor of 2, a minimum L-10 bearing life of 100,000 hours based on full motor nameplate horsepower and a minimum efficiency of 94 percent.
 - 2. Allowable Types:
 - a. Gear reduction units are required for the mixers. Gear speed reducers or increasers shall be of the single or double reduction inline type, oil- or grease-lubricated and fully sealed, or similar. The casing shall be of cast iron or heavy-duty steel construction with lifting lugs. An oil drain and inspection plug shall be provided and installed for easy access.
 - b. Gearbox may be one-stage planetary reduction gear, with a service factor of 2. The motor shaft shall be provided with a spline to attach to the gear reducer. The reduction stage shall consist of an integral toothed ring gear to which three planet wheels are mounted on the planet carriers, engaging with the pinion.
 - 3. Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.

4. Material selections shall comply with AGMA values and the manufacturer's recommendations.
 5. The area where the propeller shaft enters the pumped media shall be sealed by two totally independent mechanical shaft seals, each with its own independent single spring system. The outer mechanical seal shall be protected from solids in the pumped media by a labyrinth cast into the propeller hub/seal housing interface. An oil-filled chamber with drain and inspection plug (each with positive anti-leak seal) shall separate the seals and provide lubrication. Single mechanical seals or rotary lip seals shall not be considered adequate for this critical sealing area.
- G. Propeller: Propeller shall be of material as specified, with thick cross section to resist abrasion and to permit displacement of the stagnation point along the leading edge. Blades shall be a minimum of 3/16-inch-thick where they attach to the hub. The propeller shall be sized to accommodate the performance requirements of the mixer, as specified. The propeller shall be capable of handling solids, fibrous materials, heavy sludge, and other matter found in normal sewage applications.

2.03 SUBMERSIBLE MIXERS

- A. Design the submersible mixers for continuous full load duty and guarantee the mixers based on the design conditions specified on the data sheet. Design and construct all units to permit economical maintenance. Select all units to allow as much interchangeability of parts as possible. Unspecified details of design and construction of the mixing unit will be manufacturer's standard.

2.04 MAST ASSEMBLY/GUIDE RAIL SYSTEM FOR SUBMERSIBLE MIXERS

- A. Mast Assembly:
1. Provide a permanently installed guide mast assembly which allows for mixer installation, operation, and retrieval without the need to enter the basin. The mast shall be minimum 4-inch by 4-inch square tube or 4-inch diameter, supplied with factory welded mounting brackets at the top, bottom and intermediate levels as needed to provide support at a maximum of 10-foot intervals.
 2. The mast assembly shall be adjustable, providing adjustment of the mixer in the horizontal plane and adjustment of its vertical location. All adjustments must be possible without requiring the basin to be drained. A minimum of 160 degrees of rotation is required for the horizontal plane adjustment.

B. Materials:

1. Mast/Guide Rail System: Stainless steel.
2. Upper and Lower Support: Stainless steel.
3. Intermediate Support: Wall mounted and stainless steel.
4. Fabricated Support Frame: Stainless steel.

2.05 PORTABLE LIFTING DAVIT AND LIFTING CABLE

A. Provide two portable lifting davits suitable for use with all mixers in this section. The davit shall be designed to be mounted in a floor socket next to the mixer mast or as part of the mixer mast. Design and provide one socket for each mixer location, nine total. The lifting davit shall include a manual brake winch, and shall be adequately rated to lift the mixer and support arm off the mast and directly onto the adjacent deck surface. A removable section of handrail shall be provided by Contractor, such that the mixer does not need to be lifted over the handrail. A lifting cable, permanently attached to each mixer, shall be provided in sufficient length for attachment of the upper end to the winch cable reel when the davit assembly is installed. Provide storage area for cable when davit is not installed.

B. Materials:

1. Davit: Stainless steel.
2. Cable: Stainless steel.

2.06 ELECTRICAL COMPONENTS AND ACCESSORIES

A. Motors: Provide as indicated on mixer data sheets at the end of this section.

2.07 ACCESSORIES

- A. Anchor bolts shall be as specified in Section 05 50 00, Metal Fabrications. Number and size as recommended by manufacturer.
- B. Provide lifting lugs on equipment over 100 pounds.
- C. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
- D. Provide motor protection relays as required to interface with leak detection and temperature sensors. Relay shall be received 120V control power.

2.08 FACTORY FINISHING

- A. Prepare surface and prime coat in accordance with Section 09 90 00, Painting and Coating, System No. 2.

2.09 SOURCE QUALITY CONTROL

- A. The final acceptance of the equipment requires a field test for handling the specified fluid under specified conditions.
- B. Furnish for each unit, certified factory flow test based on measured axial flow thrust, as per proposed Hydraulic Institute Standards.
- C. Make available to the Owner without charge, all test records, whether test witnessing is required or not on the Data Sheet.

PART 3 EXECUTION**3.01 INSTALLATION**

- A. Provide stainless steel mounting bolts, washers, and nuts and install the equipment at locations indicated on the Drawings.
- B. Install the equipment in accordance with the manufacturer's instructions and typical installation detail included in this section. The manufacturer will provide for setup of the mixers during startup to optimize the mixing within the basin.
- C. Lubricants: The installation includes oil and grease for initial operation.

3.02 FIELD QUALITY CONTROL

- A. Functional Tests: Prior to acceptance of each mixer installation, each unit shall be run to demonstrate its ability to operate without overloading, jamming, excessive shaft runout, or excessive vibration.

3.03 MANUFACTURER'S SERVICES

- A. Installation, Startup, and Testing Services:
 - 1. Provide complete manufacturer's installation, startup, and testing services in accordance with Section 01 43 33, Manufacturer's Field Services.
 - 2. Provide Manufacturer's Certificate of Proper Installation.
 - 3. Provide Qualifications of Manufacturer's Representative.
- B. Training Services:
 - 1. Provide training of Owner's personnel in accordance with Section 01 43 33, Manufacturer's Field Services.

2. Provide 2 person-days of post-startup training, which shall be provided in one session within a 24-hour period to accommodate personnel working different shifts.

3.04 FIELD FINISHING

- A. Solvent clean (SP 1-82) and finish coat in accordance with Section 09 90 00, Painting and Coating, System No. 2.

3.05 MOTOR PROTECTION RELAY

- A. Deliver motor protection relay to electrical subcontractor for installation.

3.06 SUPPLEMENTS

- A. The supplements listed below, following “End of Section,” are a part of this specification.
 1. AB1 FAZ Mixer 1, AB2 FAZ Mixer 1, and AB3 FAZ Mixer 1 Data Sheet.
 2. AB1 Selector Zone Mixer 1, AB1 Selector Zone Mixer 2, AB2 Selector Zone Mixer 1, AB2 Selector Zone Mixer 2, AB3 Selector Zone Mixer 1, and AB3 Selector Zone Mixer 2 Data Sheet.

END OF SECTION

SECTION: 43 22 56.02 SUBMERSIBLE MIXER DATA SHEET

Project: Nampa WWTP Phase I Expansion Project Group A
 Owner: Nampa, ID
 Equipment Name: AB1 FAZ mixer 1, AB2 FAZ mixer 1, and AB3 FAZ mixer 1
 Equipment Tag Number(s): 4462AB1MX1, 4474AB2MX1, and 4468AB3MX1

MIXER DATA		
EQUIPMENT NAME	EQUIPMENT NUMBER	SPEED TYPE
<u>All Mixers</u>	<u>3</u>	<u>Constant Speed</u>

EQUIPMENT MANUFACTURERS	MODEL
<u>Landia</u>	<u>POP-I</u>

SERVICE CONDITIONS		PERFORMANCE REQUIREMENTS	
Liquid Mixed: <u>Aeration Basin Mixed Liquor</u>	Maximum Speed <u>390</u>	<u>rpm</u>	
Suspended Solids: <u>1,000 to 5,000 mg/L</u>		<u>gpm</u>	
Temperature: <u>50 to 75 degrees F</u>	Other Requirements: _____		
Mixed Volume: <u>52 ft x 53.3 ft x 21 ft SWD</u>			
Maximum Liquid Level: <u>21 ft</u>			
Specific Gravity: <u>1.03</u>			
Viscosity: <u>50 cp</u>			

EQUIPMENT DESCRIPTION			
Mixer Type: <u>Submersible</u>	Casing: <u>Manufacturers Standard</u>	<u>Stainless Steel or Alloy</u>	
Number of Propellers: <u>1</u>	Shaft: <u>Steel</u>		
Minimum Propeller Diameter: <u>30 inches</u>	Propellers: <u>Type 316 SST or 304 SST</u>		
Impeller Locations: _____	Lubrication: <u>Oil</u>		
Upper Position: <u>N/A</u>	Drive Type: <u>Gear Reduction</u>		
Lower Position: <u>See Drawings</u>	Mounting Type: <u>Submersible</u>		
Impeller Const: <u>Mfr. Std.</u>			

MOTOR DATA

Type: Squirrel-cage induction meeting requirements of NEMA MG 1
 Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer
 Hazardous Location: Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark
 Voltage: 460
 Motor Horsepower: 18 HP Max
 Enclosure Type: Submersible
 Phase: 3
 Horizontal Vertical
 Synchronous Speed: 1,750 rpm
 Mounting Type: _____
 Multispeed, Two-speed: _____ rpm
 Winding: One Two
 Controlled by AFD (in future): See Section 26 29 23,
 Low-Voltage Adjustable Frequency Drive Systems
 Additional Motor Requirements: See Section 26 20 00, Low-Voltage AC Induction Motors
 Shaft Split Hollow
 Uphrust: High (<30%) Extra High (<175%)
 Special Features: Manufacturer to provide the motor seal failure moisture detection and motor high temp sensors, and motor protection relay as required.

SECTION: 43 22 56.03 SUBMERSIBLE MIXER DATA SHEET		
Project: Nampa WWTP Phase I Expansion Project Group A		
Owner: Nampa, ID		
Equipment Name: AB1 Selector Zone mixer 1, AB1 Selector Zone mixer 2, AB2 Selector Zone mixer 1, AB2 Selector Zone mixer 2, AB3 Selector Zone mixer 1, and AB3 Selector Zone mixer 2		
Equipment Tag Number(s): 4460AB1MX1, 4461AB1MX2, 4472AB2MX1, 4473AB2MX2, 4478AB3MX1, and 4467AB3MX2		
MIXER DATA		
EQUIPMENT NAME	EQUIPMENT NUMBER	SPEED TYPE
All mixers	6	Constant Speed
EQUIPMENT MANUFACTURERS		MODEL
Landia		POP-I
SERVICE CONDITIONS		PERFORMANCE REQUIREMENTS
Liquid Mixed:	Aeration Basin Mixed Liquor	Maximum Speed <u>390</u> rpm
Suspended Solids:	<u>1,000 to 5,000 mg/L</u>	
Temperature	<u>50 to 75 degrees F</u>	
Mixed Volume:	<u>82 ft x 53.3 ft x 21 ft SWD</u>	Other Requirements: _____
Maximum Liquid Level:	<u>21ft</u>	
Specific Gravity:	<u>1.03</u>	
Viscosity:	<u>50 cp</u>	
EQUIPMENT DESCRIPTION		
Mixer Type: <u>Submersible</u>	Casing: <u>Manufacturers Standard</u>	<u>Stainless Steel or Alloy</u>
Number of Propellers: <u>1</u>	Shaft: <u>Steel</u>	
Minimum Propeller Diameter <u>30 inches</u>	Propellers: <u>Type 316 SST or 304 SST</u>	
Impeller Locations: _____	Lubrication: <u>Oil</u>	
Upper Position: <u>N/A</u>	Drive Type: <u>Gear Reduction</u>	
Lower Position: <u>See Drawings</u>	Mounting Type: <u>Submersible</u>	
Impeller Const: <u>Mfr. Std.</u>		
MOTOR DATA		
Type: Squirrel-cage induction meeting requirements of NEMA MG 1		
Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer		
Hazardous Location: <input type="checkbox"/>	Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark	
Motor Horsepower: <u>15 HP Max</u>	Voltage: <u>460</u>	
Phase: <u>3</u>	Enclosure Type: <u>Submersible</u>	<input type="checkbox"/> Horizontal <input type="checkbox"/> Vertical
Synchronous Speed: <u>1,750</u> rpm	Mounting Type: _____	multi-speed, 1 wo-speed: _____ rpm
Winding: <input checked="" type="checkbox"/> One <input type="checkbox"/> Two	<input type="checkbox"/>	Controlled by AFD (in future): See Section 26 29 23,
		<input type="checkbox"/> Low-voltage Adjustable Frequency Drive Systems
Additional Motor Requirements: See Section 26 20 00, Low-Voltage AC Induction Motors		
Shaft <input type="checkbox"/> Split <input type="checkbox"/> Hollow		
Upthrust: <input type="checkbox"/> High (<30%) <input type="checkbox"/> Extra High (<175%)		
Special Features:	Manufacturer to provide the motor seal failure moisture detection and motor high temp sensors. Provide motor protection relay as required.	

SECTION 44 42 28
WEIR AND BAFFLE PLATES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): F102, Matched-Die-Molded, Fiberglass-Reinforced Plastic Weir Plates, Scum Baffles, and Mounting Brackets.
2. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - c. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - d. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - e. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - f. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
 - g. C581, Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.
 - h. C920, Standard Specification for Elastomeric Joint Sealants.
 - i. D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
 - j. D570, Standard Test Method for Water Absorption of Plastics.
 - k. D638, Standard Test Method for Tensile Properties of Plastics.
 - l. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - m. D2583, Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Detailed description of laminate and type of reinforcing to be used.
 - b. Manufacturer's drawings showing dimensions of the items and accessories being provided.
 - c. Complete information regarding specific resin to be used.
2. Sample: Manufacturer's 6-inch square sample of fiberglass reinforced plastic laminate of same construction, nominal thickness, and color as materials specified.

B. Informational Submittals: Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, and stating the following:

1. Reinforcing material used will provide suitable chemical resistance.
2. Resin is suitable for the environmental conditions intended and the fabrication technique proposed.

1.03 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site properly packaged for ease of handling and to minimize damage during shipping.
- B. Handling and storage of items provided hereunder shall be in strict accordance with manufacturer's printed instructions. Care shall be taken not to damage components and accessories.

PART 2 PRODUCTS

2.01 GENERAL

- A. Like items of equipment specified herein shall be the end products of one manufacturer in order to achieve standardization of appearance, operation, maintenance, and manufacturers' services.
- B. Coordinate scum baffle configuration with equipment, such as a scum skimmer, that will physically interface with baffle to ensure proper functioning of system.

2.02 MATERIALS

A. Fiberglass:

1. Match-die molded fiberglass, 1/4-inch minimum thickness, in accordance with AWWA F102.
2. Resin: Except as modified by this specification, conform to ASTM C581:
 - a. Type II: Suitable for intended service; premium grade and corrosion-resistant such as chlorendic polyester, vinyl ester, or bisphenol A fumarate polyester.
 - b. Shall not contain fillers or thixotropic agents, except as may be required, and shall conform to resin manufacturer’s recommendations.
 - 1) Glass Content: 20 percent to 30 percent.
 - 2) Inorganic Fillers: No less than 40 percent of resin mixture.
 - c. Coloring: Pigmented gel-coat containing ultra-violet blocking agent; manufacturer’s standard color.
 - d. Sufficient thixotropic agents to form a paste to seal machined or cut edges.
 - e. Reinforcement:
 - 1) Commercial grade glass, made specifically for use in fiberglass reinforced plastic, and having a coupling agent providing a compatible bond between the glass reinforcement and the resin.
 - 2) Weight and density may be varied to obtain necessary resin-glass ratio and structural strength for the specified service.
 - f. Mold Surfaces: Reinforced with surfacing mat, followed by minimum of 3 ounces of chopped strand mat, in a minimum of two layers, with no other product introduced between layers.
 - g. Exposed Surfaces:
 - 1) Resin-rich, 10 mils to 20-mils thick with Type C surfacing mat, silane finish, and styrene-soluble binder.
 - 2) Glass fibers shall not be exposed.
 - 3) Chopped strand and chopped strand mat shall be Type E glass with silane finish and styrene-soluble binder.
 - 4) Minimum Glass Content: 30 percent by weight.
 - h. Laminates:

Property (70 Degrees F)	ASTM Standard	Value
Ultimate Tensile Strength, psi	D638	7,500 minimum
Flexural Strength, psi	D790	16,000 minimum

Property (70 Degrees F)	ASTM Standard	Value
Ultimate Tensile Strength, psi	D638	7,500 minimum
Flexural Modulus, psi	D790	800,000 minimum
Water Absorption	D570	0.2% in 24 hours
Impact, foot-pounds	D256	10

- i. Barcoal Hardness: ASTM D2583; minimum 90 percent of resin manufacturer’s minimum specified hardness for cured, nonreinforced resin.
- j. Allowable cosmetic defects: As defined in AWWA F102.
- k. Final Laminate:
 - 1) Thickness: Within plus or minus 10 percent of nominal laminate thickness.
 - 2) Tolerance: Plus 1/16 inch; minus 0 inch of minimum specified thickness.
 - 3) Void Content (Completed Laminate): Maximum 2-1/2 percent of laminate by volume.
- 3. Manufacturers:
 - a. MFG Water Treatment Products Company, Union City, PA.
 - b. NEFCO, Inc., Palm Beach Gardens, FL.
 - c. Strongwell Corp., Bristol, VA.

2.03 APPURTENANCES

- A. Sealant:
 - 1. Polyurethane base, single-component, moisture curing, ASTM C920, Type S, Grade NS or P, Class 25.
 - 2. Capable of being continuously immersed in water.
 - 3. Manufacturers and products:
 - a. Sika Chemical Corp.; Sikaflex-1a.
 - b. Mameco International; Vulkem 45.
- B. Anchoring: Type 316 stainless steel adhesive anchors as specified in Section 05 50 00, Metal Fabrications.

PART 3 EXECUTION**3.01 INSTALLATION**

- A. Install in strict accordance with the manufacturer's written instructions.
- B. FRP Plates: Sand all cut edges or drilled holes greater than 3/8 inch in diameter, and seal with a nonair-inhibited resin solution, as recommended by resin manufacturer.
- C. Install weir plates such that weir crest is level with a maximum variation of 1/16 inch throughout its entire length.
- D. Sealant:
 - 1. Clean and prepare concrete and weir plate surfaces in accordance with sealant manufacturer's recommendations.
 - 2. Application:
 - a. In accordance with manufacturer's instructions.
 - b. Completely cover the interface between the weir plate and mounting surface over the full height of the weir plate.
 - c. Apply sufficiently to completely fill any gaps between the weir plate and the supporting wall surface.
 - d. Clean excess sealant that is forced from between the weir plate and supporting wall as the plate is tightened against the wall surface to provide a neat installation.
 - e. Clean all adjacent surfaces of smears or soiling.

3.02 TESTS AND INSPECTION

- A. In accordance with Section 01 75 00, Testing, Equipment Startup, and Commissioning.
- B. Functional Test: Demonstrate proper installation of weir plate for both water tightness and level, prior to placing unit into service, by filling unit with water to the weir crest elevation. Make adjustments as necessary to meet specification.

END OF SECTION

**SECTION 44 42 56.03
VERTICAL TURBINE SOLIDS HANDLING PUMPS**

EQUIPMENT AND COMPONENT NUMBER(S)

Equipment Number	Equipment Name
3401PEPU1	PRIMARY EFFLUENT PUMP 1
3402PEPU2	PRIMARY EFFLUENT PUMP 2
3403PEPU3	PRIMARY EFFLUENT PUMP 3

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

- A. See Division 01, General Requirements, which contains information and requirements that apply to the Work specified herein and are mandatory for this Project.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Bearing Manufacturers Association (ABMA):
 - a. 9, Load Ratings and Fatigue Life for Ball Bearings.
 - b. 11, Load Ratings and Fatigue Life for Roller Bearings.
 2. ASTM International (ASTM):
 - a. A36/A36M, Standard Specification for Carbon Structural Steel.
 - b. A536, Standard Specification for Ductile Iron Castings.
 - c. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
 3. Hydraulic Institute Standards (HIS):
 - a. 9.6.4, Rotodynamic Pumps for Vibration Measurements and Allowable Values.
 - b. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
 4. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.
 5. NSF International (NSF): 61, Drinking Water System Components – Health Effects.

1.03 DEFINITIONS

- A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.04 SUBMITTALS

- A. Action Submittals (The information listed under 1, 2 and 3 plus a non-certified assembly drawing shall be submitted with the bid proposal and shall be submitted again with the post-award submittal by the selected supplier):

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity. Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions.
4. Pump maximum downthrust or upthrust in pounds.
5. Detailed structural, mechanical, and electrical drawings showing equipment dimensions, size, and locations of connections and weights of components.
6. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, parts nomenclature, and materials of construction lists.
7. Baseplate drawings with leveling jackscrew details, anchor bolt and sleeve details, and minimum foundation installation and leveling requirements.
8. Complete motor nameplate data, as defined by NEMA, motor manufacturer, including motor modifications.
9. Factory finish system.
10. Information and drawings on flow indicator/low flow switch and hydrocone.

- B. Informational Submittals:

1. Manufacturer's Certification of Compliance that factory finish system is identical to requirements specified herein.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.
4. Factory Functional and Performance Test Reports. Factory test data for each pump shall be submitted, reviewed, and approved by Engineer prior to shipment of equipment.
5. Operation and Maintenance Data: As specified in Section 01 76 00, Operating and Maintenance Information.

6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.05 EXTRA MATERIALS

- A. Furnish for this set of pumps:
 1. Complete set packing.
 2. Complete set of bowl and lineshaft bearings.
 3. Complete set gaskets and O-ring seals.
 4. Complete set of shaft sleeves.
 5. Complete set keys, dowels, pins, etc.
 6. Impeller.
 7. Impeller shaft.
 8. Bowl wear ring.

PART 2 PRODUCTS

2.01 GENERAL

- A. Pumps shall be vertical turbine solids handling pump, specifically designed to pump fluid with solids and keep the bowl and lineshaft bearings from operating in the pumped fluid.
 1. Pump shall have a non-clog impeller design and be able to pass 4-inch solids.
 2. Seal water flush shall be carried to the lineshaft bearings and to the bowl bearings by the enclosed lineshaft tube.
- B. Lateral and Torsional Vibrations:
 1. Pump and motor assembly shall have no first or second order natural frequencies within 20 percent of operating speed range or impeller blade pass frequency.
 2. Fundamental critical speed of rotating assembly shall be no less than 20 percent above the rated speed.
 1. Pump manufacturer shall conduct an analysis of the lateral and torsional vibration of pump and motor assembly.
 - a. Perform a finite element structural dynamic analysis of the combined discharge head and motor. The structural dynamic analysis shall predict no first or second bending mode frequencies within a range from 20 below minimum operating speed to 20 percent above maximum operating speed.
 - b. Perform a lateral rotodynamic analysis of the motor, pump shaft and impeller assembly. The analysis shall verify that the first lateral critical speed shall be 20 below minimum operating speed to 20 percent above maximum operating speed. Any pump

component excited resonant frequency shall be no closer the plus or minus 20 percent of the natural resonant frequency of any part of the installed assembled pumping unit.

- c. Perform a torsional rotodynamic analysis of the motor, pump shaft and impeller assembly. The analysis shall verify that the first lateral critical speed shall be 20 below minimum operating speed to 20 percent above maximum operating speed.

2.02 SUPPLEMENTS

- A. Some specific requirements are attached to this section as supplements.

2.03 SHAFT SEALS

- A. Sealing system for vertical turbine solids handling pump shafts shall be packed stuffing box.

- B. Packing Requirements:

1. Stuffing Box:
 - a. Tap to permit introduction of seal liquid.
 - b. Hold a minimum of three rows of packing and a lantern ring.
 - c. Face attached.
 - d. Box and shaft shall be suitable for field installation without machining or other modifications for applicable pump and operating conditions.
2. Packing Rings:
 - a. Asbestos free die-molded packing rings of braided graphite material free of PTFE. A.W. Chesterton Company; 1400R or equal.
 - b. Glands: Two-piece split construction.
3. External Seal Water:
 - a. Seal water flow control and monitoring equipment will be provided by the installing Contractor.
 - b. External Seal Water: Screened and chlorinated wastewater treatment plant effluent water.
 - c. Flow: 1 gallon to 2 gallons per min flow rate, plus or minus 10 percent accuracy.
4. Shaft Sleeve:
 - a. Fit section of shaft that extends through or into stuffing box with replaceable stainless steel sleeve with a Brinell hardness of not less than 500.
 - b. Sleeve shall be held to shaft to prevent rotation.
 - c. Gasketed to prevent leakage between shaft and sleeve.
 - d. Thickness: 3/8 inch minimum.

2.04 ACCESSORIES

- A. Flow Indicator and Low Flow Switch: Provide a flow indicator and low flow switch for the seal water. Low flow switch shall be a contact that closes when seal water flow falls below the recommended amount by more than 20 percent. Switch shall be rated for 5 amps at 120V ac. Switch shall be Hedland Flow-Alert switch, or equal.
- B. Hydrocone: Provide a cone-shaped vortex inhibitor to mount on the floor of the wet well under the intake bell of each pump. Cone shall be fabricated from Type 304 stainless steel and shall mount to the floor of the wet well with a minimum of four anchor bolts.
- C. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.
- D. Lifting Lugs: Equipment weighing over 100 pounds.
- E. Anchor bolts shall be as specified in Section 05 50 00, Metal Fabrications. Number and size as recommended by manufacturer.

2.05 FACTORY FINISHING

- A. Prepare and prime and finish coat:
 - 1. Surface preparation and coating shall be System No. 2 as specified in Section 09 90 00, Painting and Coating.
 - 2. Provide the coating to the outside of the bowl, inside and outside of the column, outside of tube and inside and outside of the discharge head.

2.06 SOURCE QUALITY CONTROL

- A. Factory Tests and Adjustments: Test all equipment furnished.
- B. Factory Test Report: Include certified curve test results.
- C. Functional Test: Perform manufacturer's standard test on pumps and motors. Include vibration test, as follows:
 - 1. Dynamically balance rotating parts of each pump and its driving unit before final assembly.
 - 2. Limits:
 - a. Driving Unit Alone: Less than 80 percent of NEMA MG 1 limits.
 - b. Pump Impeller: ISO 1940 Grade 2.5 limit in accordance with procedures outlined in Hydraulic Institute Standard 9.6.4 Appendix B.

D. Performance Test:

1. Conduct on each pump at rated speed.
2. Perform under simulated operating conditions.
3. Test for a continuous 1-hour period without malfunction.
4. Test Log: Record the following:
 - a. Total head.
 - b. Capacity.
 - c. Horsepower requirements.
 - d. Flow measured by factory instrumentation and storage volumes.
 - e. Average distance from suction well water surface to pump discharge centerline for duration of test.
 - f. Pump discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.
 - g. Calculated velocity head at the discharge flange.
 - h. Bowl head.
 - i. Driving motor voltage and amperage measured for each phase.
5. Adjust, realign, or modify units and retest in accordance with Hydraulic Institute Standards if necessary.
6. Submit a copy of the certified test curve for the pump head, power and hydraulic efficiency plotted against flow.
7. Also submit a family of curves, based on the certified test curves, for speeds that include 100 percent, 80 percent, 60 percent, 50 percent, and 40 percent speed. Include head, power and hydraulic efficiency plotted against flow.

E. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.

PART 3 EXECUTION

3.01 MANUFACTURER’S SERVICES

- A. The successful bidder shall provide services as described below when the pumps are installed by the installing Contractor. The Manufacturer’s Representative shall coordinate these services with the installing Contractor, and schedule the required site visit and services with this Contractor.
- B. Manufacturer’s Representative: Present at Site or classroom designated by Owner for minimum person-days listed below, travel time excluded:
 1. 1 person-day for installation assistance and inspection.
 2. 2 person-days for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.
 3. 1 person-day for prestartup classroom or Site training.
 4. 1 person-day for facility startup.

5. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer.

C. See Section 01 43 33, Manufacturers' Field Services.

3.02 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Vibration Test:
 - a. Test with unit installed and in normal operation, and discharging to connected piping systems at rates between low discharge head and high discharge head conditions specified with the pump operating in its Preferred Operating region, and with actual building structures and foundations provided. Pump shall not develop vibration exceeding 80 percent of limits specified in HIS 9.6.4.
 - b. If unit exhibits vibration in excess of limits specified, adjust or modify as necessary. Unit that cannot be adjusted or modified to conform as specified shall be replaced.
3. Flow Output: Measured by plant instrumentation and storage volumes.
4. Operating Temperatures: Monitor bearing areas on pump motor for abnormally high temperatures.
5. Test for continuous 3-hour period.
6. Test Report Requirements: In accordance with HIS 14.6.

3.03 SUPPLEMENTS

- A. The supplement listed below, following "End of Section," is a part of this Specification.
1. Primary Effluent Pumps Data Sheet.

END OF SECTION

VERTICAL TURBINE PUMP DATA SHEET, 44 42 56.03Tag Numbers: 3401PEPU1, 3402PEPU2, 3403PEPU3Pump Name: Primary Effluent PumpsManufacturers and Product: (1) Fairbanks Morse Model 20 VTSH(2) Flowserve 20 MVX(3) Or Equal**SERVICE CONDITIONS**Liquid Pumped: Municipal wastewater primary clarifier effluentPumping Temperature (Fahrenheit): Normal 70 Max 80 Min 60Specific Gravity at 60 Degrees F: 1.0 Viscosity Range: 50 to 70 cpAbrasive (Y/N): N Possible Scale Buildup (Y/N): NCorrosive (Y/N): NTotal suspended solids (mg/l) 2,000Min. NPSH Available (Ft. Absolute): 38Altitude (Feet above Mean Sea Level): 2,480Area Classification: Non-classifiedAmbient Temperature (degrees F.): -10 to 110 FLocation: Indoor (Y/N): NOutdoor (Y/N): Y**PERFORMANCE REQUIREMENTS**

Condition	Flow - GPM	Head - Feet	Horsepower
Peak (Rated) Flow	9,450	30	86
Mid-range Flow	6,300	29	55
Minimum Flow	3,000	14	14

The Peak and Mid-range flows shall be within the Preferred Operating Range of the pump. The Minimum flow shall be within the Allowable Operating Range of the pump.

Min. Pump Hydraulic Efficiency at Rated Capacity (%): 83

Max. NPSH Required at Rated Capacity (Ft. Absolute): 30

Max. Pump Speed at Rated Capacity (rpm): 720

Constant (Y/N): N

Adjustable (Y/N): Y

DESIGN AND MATERIALS

Pump Type: Enclosed Line Shaft

Bowl: Cast iron Bowl Wear Rings: Stainless steel, if used

Bowl and Suction Bell Maximum Diameter (inches): 40

Bowl Bearings: Bronze or bronze-backed neoprene rubber. Bowl bearings shall be enclosed and lubricated by the flushing water that lubricates the line shaft bearings.

Column: Flanged steel, coated and lined, 10-inch minimum size

Line Shafting: Stainless Steel Max. Bearing Span (Feet): 3

Line Shaft Bearings: Bronze

Discharge Head:

Type: Above grade discharge with stiffeners as required to limit vibration to the stated allowable limits.

Material: Fabricated Steel, ASTM A36/A36M

Discharge Nozzle Size (inches): 20 Flange Standard/Class: ANSI 150

Impeller:

Type: Enclosed or semi-open, non-clog style

Material: Cast iron or bronze

Head Shaft Material: Carbon steel Shaft Sleeve Material: Stainless steel

Shaft Sealing: Packing

Seal Lubrication: Recycled plant effluent from an external source

Sole Plate (Y/N) Y

Carbon Steel Soleplate: Provide for support of pump assembly, including thrust and dynamic loads. Top of soleplate shall be faced, drilled, and tapped for pump baseplate.

DRIVE MOTOR (See Section: 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 100 Voltage: 460 Phase: 3

Synchronous Speed (rpm): 600 or 720

Service Factor: 1.0 Inverter Duty Rated

Motor nameplate horsepower shall not be exceeded at any head-capacity point on pump curve.

Enclosure: TEFC

Mounting Type: Vertical Solid Shaft

ABMA 9 and ABMA 11, B-10 Motor Bearing Life (hrs): 50,000

Adjustable Speed Drive Range: 40 percent min to 100 percent max.

Motor Winding Temperature Sensors and Motor Space Heaters: Provide in accordance with Section 26 20 00, Low-Voltage AC Induction Motors

**SECTION 44 42 56.04
SUBMERSIBLE PUMPS**

EQUIPMENT AND COMPONENT NUMBER(S)

Equipment Number	Equipment Name
4401UDPMP1	Aeration Basin 3 Underdrain Pump 1
4402UDPMP2	Aeration Basin 3 Underdrain Pump 2
4487AB3DW3	Dewatering Sump Pump 3

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

- A. See Division 01, General Requirements, which contains information and requirements that apply to the Work specified herein and are mandatory for this Project.

1.02 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American Bearing Manufacturers Association (ABMA):
 - a. 9, Load Ratings and Fatigue Life for Ball Bearings.
 - b. 11, Load Rating and Fatigue Life for Roller Bearings.
 2. American Society of Mechanical Engineers (ASME): B16.1, Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 150.
 3. ASTM International (ASTM):
 - a. A48, Standard Specification for Gray Iron Castings.
 - b. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
 4. Hydraulic Institute Standards (HIS):
 - a. 11.6, Submersible Pump Test.
 - b. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
 5. National Electrical Manufacturers Association (NEMA).
 6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code.
 - b. 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.
 7. Underwriters Laboratories Inc. (UL).

1.03 DEFINITIONS

- A. Terminology pertaining to pumping unit performance and construction shall conform to ratings and nomenclature of Hydraulic Institute Standards.

1.04 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction, including cable seal details.
3. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over entire operating range of pump, from shutoff to maximum capacity. Indicate separately head, capacity, horsepower demand, overall efficiency, and minimum submergence required at guarantee point.
4. For variable speed motors, provide variable speed curves for every 50 rpm over the operational range.
5. Power and control wiring diagrams, including terminals and numbers.
6. Motor data, in accordance with the requirements of Section 26 20 00, Low-Voltage AC Induction Motors.
7. Factory-finish system.
8. L-10 bearing life calculations per ABMA.
9. If required, wiring for motor protection module.
10. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Anchorage and Bracing Requirements.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 60 01, Anchorage and Bracing Requirements.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.
4. Suggested spare parts list to maintain equipment in service for period of 1 year. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
5. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
6. Operation and Maintenance Data as specified in Section 01 76 00, Operating and Maintenance Data Information.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.05 EXTRA MATERIALS

- A. Furnish for this set of pumps:
 - 1. One set mechanical seals for one pump.
 - 2. One complete set of special tools required to dismantle pump.

PART 2 PRODUCTS**2.01 GENERAL**

- A. Submersible, vertical shaft, centrifugal nonclog type, for pumping wastewater.
- B. Designed for continuous operation under submerged or partially submerged conditions, and intermittent operation when totally dry without damage to pump or motor.
- C. Pump and Electrical Driver: Meet requirements for class, group, and division location in accordance with NFPA 70.
- D. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.
- E. Pumps furnished under this section to be provided by a single manufacturer.

2.02 SUPPLEMENTS

- A. Specific requirements are attached to this section as supplements.

2.03 COMPONENTS

- A. Equipment consists of pump complete with motor, control system, guide rail, anchoring brackets, base elbow, power cable, and pump lifting cable.
- B. Characteristics:
 - 1. Motor and rotating parts shall be removable from motor end of pump.
 - 2. Mating surfaces to be watertight and fitted with nitrile O-rings.
 - 3. Pumps fitted with dynamically balanced nonclog impellers designed to pass course solids and stringy materials.
- C. Lifting Arrangement:
 - 1. Stainless steel chain, 2 feet minimum, and one “grip-eye.”
 - 2. Attach chain permanently to pump and sump lid with stainless steel wire rope.

3. “Grip-eye” capable of being threaded over and engaging links of stainless steel chain so pump and motor may be lifted with “grip-eye” and independent hoist.

D. Sliding Guide Bracket:

1. Integral part of pump unit.
2. Pump unit to be guided by no less than two guide bars, or equivalent cable system, and pressed tightly against discharge connection elbow with metal-to-metal contact or through use of profile-type gasket, provided gasket is attached to pump’s flange and can be easily accessed for inspection when pump is lifted out of wetwell.

E. Motor nameplate horsepower not to be exceeded at any point on pump curve.

F. Pump motor and sensor cables shall be suitable for submersible pump application and cable sizing shall conform to NFPA 70 specifications for pump motors. Cables shall be of sufficient length to reach junction boxes without strain or splicing.

G. Motor Protection Module: If required, provide pump with a motor protection module for remote mounting. Contract Drawings are based on first named submersible pump manufacturer and motor protection module. If pump and motor protection module other than first named manufacturer is provided, provide revised wiring for the motor protection module.

H. Cable Entry System:

1. Junction chamber and motor separated by stator lead sealing gland or terminal board that prevents foreign material entering through pump top.
2. Utilize cable with factory-installed sealing gland with nonshrink epoxy seal system.
3. O-ring compression seal between sealing gland and cable entry point shall also be acceptable.

2.04 ACCESSORIES

- A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
- B. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.05 FACTORY FINISHING

- A. Prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.
- B. System No. 2.

2.06 SOURCE QUALITY CONTROL

- A. Pump:
 - 1. Factory Performance Test:
 - a. In accordance with HIS 11.6, Level B for submersible pump tests.
 - b. Include test data sheets curve test results performance test logs.
 - 2. Conduct on each pump.
 - 3. Perform under actual or approved simulated operating conditions.
- B. Submersible Motor Functional Test: In accordance with HIS 11.6.

PART 3 EXECUTION**3.01 INSTALLATION**

- A. Install in accordance with manufacturer's printed instructions.
- B. Mount the discharge elbow to the floor of the wetwell floor with stainless steel bolts.
- C. Connect piping without imposing strain to flanges.
- D. No portion of pump shall bear directly on floor of sump.

3.02 FIELD QUALITY CONTROL

- A. Functional Test: Conduct on each pump.
 - 1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
 - 2. Test for continuous 1-hour period.
 - 3. Test Report Requirements: In accordance with Hydraulic Institute Standards for submersible pump tests HIS 14.6 and 11.6.
- B. Pump Test:
 - 1. General:
 - a. Conduct on each pump provided.
 - b. Conduct in accordance with HIS 11.6.

2. Routine Production Tests:
 - a. Check impeller, motor rating and electrical connections for compliance to specification.
 - b. Test motor and cable insulation for moisture content and insulation defects.
 - c. Prior to submergence, run pump dry to establish correct rotation and mechanical integrity.
 - d. Conduct abbreviated three-point operational performance test.
 - e. After operational performance test, perform insulation test again.

3.03 MANUFACTURER’S SERVICES

- A. Manufacturer’s Representative: Present at Site or classroom designated by Owner’s Representative, for minimum person-days listed below, travel time excluded:
 1. 1/2 person-day for installation assistance and inspection.
 2. 1 person-day for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.
 3. 1/2 person-day for prestartup classroom or Site training.
 4. 1/2 person-day for facility startup.
 5. 1 person-day for post-startup training of Owner’s personnel. Training shall not commence until accepted detailed lesson plan for each training activity has been reviewed by Owner Engineer.
- B. See Section 01 43 33, Manufacturers’ Field Services, and Section 01 75 00, Testing, Equipment Startup, and Commissioning.

3.04 SUPPLEMENTS

- A. The supplements listed below, following “End of Section,” are part of this Specification.
 1. Aeration Basin Underdrain Pumps 1 and 2 Data Sheet.
 2. Dewatering Sump Pump 3 Data Sheet.

END OF SECTION

SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04Tag Numbers: 4401UDPMP1, 4402UDPMP2Pump Name: Aeration Basin Underdrain Pumps 1 and 2Manufacturer and Model Number: (1) Barnes, 4SE11344L

(2) _____

SERVICE CONDITIONSLiquid Pumped (Material and Percent Solids): GroundwaterPumping Temperature (Fahrenheit): Normal: 65 Max _____ Min _____Specific Gravity at 60 Degrees F: 1.0 Viscosity Range: 1.210x10⁻⁵ ft²/spH: 6-9Abrasive (Y/N) Y Possible Scale Buildup (Y/N): N

Total suspended solids (mg/L) _____.

Minimum diameter solid pump can pass (inches) 3

Min. NPSH Available (Ft. Absolute): _____

PERFORMANCE REQUIREMENTSCapacity (US gpm): Rated: 600Total Dynamic Head (Ft): Rated: 20

Min. Rated Pump Hydraulic Efficiency at Rated Capacity (%): _____

Max. Pump Speed at Rated Capacity (rpm): Constant (Y/N): Y
Adjustable (Y/N): _____**DESIGN AND MATERIALS**Pump Type: Heavy-Duty Nonclog (Y/N) Y Other: _____Volute Material: Cast Iron ASTM A48Pump Casing Material: Cast Iron ASTM A48Motor Housing Material: Cast Iron ASTM A48

Wear Rings Case (Y/N): N Material: _____

Wear Ring Impeller (Y/N): N Material: _____

Elastomers: Buna-N

Fasteners: Stainless Steel

Impeller: Type: Double-Shrouded Non-Clog (Y/N): N Other: _____
Material: Cast Iron ASTM A48

Shaft Material: Carbon Steel, ASTM A576 with stainless steel sleeve or all stainless steel.

Base Elbow: Cast Iron ASTM A48

Double Mechanical Seal (Y/N): Y Bearing Life (Hrs): 50,000

DRIVE MOTOR (See Section 26 20 00, Low-Voltage AC Induction Motors.)

Horsepower: 11.3 Voltage: 480 Phase: 3 Synchronous Speed (rpm): 1750

Enclosure: Submersible

Other Features: _____

Moisture Detection Switches (Y/N): Y

Thermal Protection Embedded in Windings (Y/N): Y

REMARKS: Provide motor leak protection and temperature protection relays to electrical contractor for installation.

SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04

Tag Numbers: 4487AB3DW3

Pump Name: Dewatering Sump Pump 3

Manufacturer: (1) Flygt

(2) ABS

SERVICE CONDITIONS

Liquid Pumped (Material and Percent Solids): Mixed liquor

Pumping Temperature (Fahrenheit): Normal: 70 Max _____ Min _____

Specific Gravity at 60 Degrees F: 1.0 Viscosity Range: 40 – 60 cp

pH: 6-9

Abrasive (Y/N) N Possible Scale Buildup (Y/N): N

Total suspended solids (mg/L) 3000 – 10000

Minimum diameter solid pump can pass (inches) 3

Min. NPSH Available (Ft. Absolute): 30

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 1300

Total Dynamic Head (Ft): Rated: 22

Min. Rated Pump Hydraulic Efficiency at Rated Capacity (%): _____

Max. Pump Speed at Rated Capacity (rpm): 1750 Constant (Y/N): Y

Adjustable (Y/N): N

DESIGN AND MATERIALS

Pump Type: Heavy-Duty Nonclog (Y/N) Y Other: _____

Volute Material: Cast Iron ASTM A48

Pump Casing Material: Cast Iron ASTM A48

Motor Housing Material: Cast Iron ASTM A48

Wear Rings Case (Y/N): Y Material: Stainless Steel

Wear Ring Impeller (Y/N): N Material: _____

Elastomers: Buna-N

Fasteners: Stainless Steel

Impeller: Type: Double-Shrouded Non-Clog (Y/N): Y Other: _____
 Material: Cast Iron ASTM A48

Shaft Material: Carbon Steel, ASTM A576 with stainless steel sleeve or all stainless steel.

Base Elbow: Cast Iron ASTM A48

Double Mechanical Seal (Y/N): Y Bearing Life (Hrs): 50,000

DRIVE MOTOR (See Section 26 20 00, Low-Voltage AC Induction Motors.)

Horsepower: 20 Voltage: 480 Phase: 3 Synchronous Speed (rpm): 1750

Enclosure: Submersible

Other Features: _____

Moisture Detection Switches (Y/N): Y

Thermal Protection Embedded in Windings (Y/N): Y

REMARKS: Provide motor leak protection and temperature protection relays to electrical contractor for installation.

Coordinate with base elbows in Aeration Basins 1 and 2 and provide an adapter flange that will allow this pump to be installed on the existing rails/base elbow assembly in aeration Basins 1 and 2. An existing dewatering pump is available for inspection at the wastewater treatment plant if arrangements are made to view during one of the scheduled preconstruction tours.

SECTION 44 45 16.02
FINE BUBBLE AIR DIFFUSER SYSTEM

EQUIPMENT AND COMPONENT NUMBERS**PART 1 GENERAL**

1.01 GENERAL REQUIREMENTS

- A. General Requirements: See Division 01, General Requirements, which contains information and requirements that apply to the Work specified herein and are mandatory for this Project.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Civil Engineers (ASCE): 2, Measurement of Oxygen Transfer in Clean Water.
 2. American Society of Mechanical Engineers (ASME): B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard.
 3. ASTM International (ASTM):
 - a. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 - b. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications.
 - c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - d. D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

1.03 DEFINITIONS

- A. Adequate Mixing: Variation in mixed liquor suspended solids (total residue) of less than 10 percent between the mean value of Samples taken at any two depths along any vertical line extending between water surface and elevation of the top of diffusers.
- B. Basin: Structure within which aeration occurs.
- C. Bay: Portion of grid on each side of drop leg and manifold assembly.

- D. Diffuser Assembly: Flexible membrane or ceramic diffuser with an element holder and retaining device.
- E. Distribution Header: Piping between manifold and diffuser assembly.
- F. Drop Leg: Connection from air source to manifold.
- G. Dynamic Wet Pressure (DWP): Pressure to operate at specified conditions minus submergence and flow control losses.
- H. Grid: Configuration of diffuser system in a zone.
- I. Manifold: Single run of piping that connects drop leg with distribution header(s).
- J. Specific Permeability Rating: Number of cubic feet of air per minute at 70 degrees F (plus or minus 5 percent) and 10 percent to 50 percent relative humidity that will pass through 1 square foot of diffuser element materials, 1-inch thick with a differential pressure equivalent of 2-inch water column (ceramic only).
- K. Standard Cubic Feet per Minute (scfm): Air at 68 degrees F, 14.7 psia, and 36 percent relative humidity.
- L. Standard Oxygen Transfer Rate (SOTR): Rate of oxygen transfer to tap water at standard conditions of 20 degrees C, 0.0 mg/L residual dissolved oxygen concentration, and a barometric pressure of 760 mm Hg (dry air).
- M. Zone: Area within an aeration basin used to provide a particular type or level of treatment.
 - 1. Each aeration basin consists of the following zones:
 - a. Selector Zone.
 - b. Flexible Aerated Zone (FAZ).
 - c. Aeration Zone 1.
 - d. Aeration Zone 2.
 - e. Aeration Zone 3.
 - f. Aeration Zone 4.

1.04 PERFORMANCE REQUIREMENTS

- A. Airflow Rate Output: Not differ by more than 10 percent, at minimum and maximum airflows, for any two system diffusers (based on diffuser with lower flow rate).

- B. Air Distribution and Balancing: Control by use of orifices and proper header size selection only.
- C. Do not use flow distribution control devices requiring automatic or manual operation.
- D. Mixing: Adequate throughout each zone of aeration basins at stated minimum airflow requirements.
- E. Achieve Adequate Mixing in aeration basins at mixed liquor suspended solids concentrations between 1,000 and 5,000 mg/L.
- F. Air Distribution and Balancing: Sufficient to maintain mixed liquor suspended solids in a state of suspension over entire depth of aeration basin at stated minimum airflow requirements.
- G. Material being aerated is primary effluent, secondary effluent, mixed liquor, and return activated sludge.
- H. System Aeration Requirements for each Aeration Basin:
 - 1. Diffuser Airflow (scfm) per Aeration Basin:
 - a. Minimum: 3,033.
 - b. Average: 8,078.
 - c. Maximum: 12,504.
 - 2. Available Airflow FAZ (scfm per Zone):
 - a. Peak: 3,800.
 - b. Minimum: 0.
 - 3. Available Airflow Aerobic Zone 1 (scfm per Zone):
 - a. Peak: 4,800.
 - b. Minimum: 1,350.
 - 4. Available Airflow Aerobic Zone 2 (scfm per Zone):
 - a. Peak: 3,600.
 - b. Minimum: 800.
 - 5. Available Airflow Aerobic Zone 3 (scfm per Zone):
 - a. Peak: 1,600.
 - b. Minimum: 800.
 - 6. Available Airflow Aerobic Zone 4 (scfm per Zone):
 - a. Peak: 1,200.
 - b. Minimum: 800.
 - 7. SOTR FAZ Zone (Pounds of O₂ per Day per Zone):
 - a. Required: 35,200.
 - 8. SOTR Aerobic Zone 1 (Pounds of O₂ per Day per Zone):
 - a. Required: 45,700.
 - 9. SOTR Aerobic Zone 2 (Pounds of O₂ per Day per Zone):
 - a. Required: 33,500.

10. SOTR Aerobic Zone 3 (Pounds of O₂ per Day per Zone):
 - a. Required: 13,700.
11. SOTR Aerobic Zone 4 (Pounds of O₂ per Day per Zone):
 - a. Required: 10,500.

1.05 DESIGN REQUIREMENTS

- A. Furnish fixed header, fine bubble, diffused air aeration equipment system as a complete package including, but not necessarily limited to, drop leg; air manifold; distribution headers; diffusers; diffuser pressure monitoring system; supports; drainline, sump, and airlift purge; header joints; accessories; connections for gas cleaning system; and miscellaneous appurtenances.
- B. Furnish complete, engineered systems. Drawings indicate air manifold, header, and diffuser orientations only. Details such as air manifold sizes, air header sizes and spacing, air manifold and header supports and spacing, diffuser spacing, etc., shall be defined by and be the responsibility of Contractor and shall be consistent with requirements in this section.
- C. Design aeration equipment so that upon completion of installation, diffusers are level to within plus or minus 3/8 inch of a common horizontal plane.

1.06 SUBMITTALS

- A. Action Submittals:
 1. Shop Drawings:
 - a. Make, model, and weight of each equipment assembly.
 - b. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction.
 - c. Detailed mechanical drawings showing equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work, and weights of associated equipment.
 - d. A detailed drawing of proposed aeration equipment layout for each basin showing air line sizes and lengths, distances between air distribution headers, and location of diffusers, supports, and expansion joints.
 - e. Diffuser, diffuser connector, balancing orifices, and system head loss curves covering range of airflow rates specified.
 - f. Calculations showing distribution and balancing of air within each basin for minimum and maximum airflow rates specified.
 - g. Shop and Field Painting Systems Proposed: Include manufacturer's descriptive technical catalog literature and specifications.

- h. Anchorage and bracing drawings and cut sheets, as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.

B. Informational Submittals:

1. Calculations by a registered engineer to demonstrate design complies with requirements of this section.
2. Anchorage and bracing calculations as required by Section 01 60 01, Seismic Anchorage and Bracing Requirements.
3. Factory test results, reports, and certifications. Include oxygen transfer performance test.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
5. Special shipping, storage and protection, and handling instructions.
6. Operation and Maintenance Data: As specified in Section 01 76 00, Operating and Maintenance Data Information.
 - a. Include manufacturer's written/printed installation instructions with erection drawings indicating, by piece marking, how entire assembly (for each basin service) is to be shipped and field assembled.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
8. Manufacturer's special guarantee.
9. Service records for maintenance performed during construction.

1.07 SPECIAL GUARANTEE

- A. Furnish manufacturer's extended guarantee or warranty, which shall be in addition to the Contractor's 1-year correction period, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, replacement of diffuser connectors and assemblies found defective during period of 5 years after date of Substantial Completion. Manufacturer shall be responsible for material replacement of parts or materials that fail during warranty period. Down time, labor, or associated costs shall not be included in the extended warranty period beyond the Contractor's 1-year correction period.

1.08 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

<u>Item</u>	<u>Quantity</u>
Sealing gaskets	100
Flexible membrane diffuser elements	100
Diffuser element retainers	25
Element tighteners	3
Completely assembled diffusers	100
Air distribution pipe support assemblies	10
Air distribution pipe expansion joints	10
Tool sets, if required, for removal and replacement of diffuser assemblies.	2

- B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of:
 1. ITT Industries Sanitaire.
 2. No Or Equal.

2.02 SERVICE CONDITIONS

- A. System:
 1. Temperature at Mixed Liquor:
 - a. Minimum: 14.
 - b. Maximum: 25.
 2. pH of Mixed Liquor: 6.5 to 8.5.
 3. Mixed Liquor Suspended Solids Concentration:
 - a. Average: 3,000.
 - b. Maximum: 5,000.
 4. Maximum Basin Sidewater Depth: 20.6 feet.
 5. Allowable Diffuser Mounting Distance Above Basin Floor (Floor to Diffuser Element):
 - a. Minimum: 9 inches.
 - b. Maximum: 12 inches.
 6. Available Pressure at Drop Leg (psig): 8.5 to 9.5.

2.03 GENERAL

- A. Shop fabricate welded metal parts and assemblies from Type 304L stainless steel with a 2D finish conforming to ASTM A240/A240M.
- B. Shop fabricate nonwelded parts and pieces from sheets and plates of Type 304 stainless steel conforming to ASTM A240/A240M, unless specified otherwise.
- C. After fabrication, pickle and passivate stainless steel assemblies and parts in accordance with ASTM A380.
- D. Header and Header Support System: Allow for expansion and contraction over a temperature range of 125 degrees F when installed.

2.04 DROP LEG, AIR MANIFOLD, AND DISTRIBUTION HEADERS

- A. Drop Leg:
 - 1. Drop leg upper connection located approximately 3 feet below of the aeration basin top of wall as shown in design drawing. Top connection and drop leg connection to air manifold shall be loose follower flanges.
 - 2. Support from its upper connection, with additional support at lower elbow. Connection between drop leg and air manifold shall be a slip joint.
 - 3. Stainless steel to at least 3 feet from the bottom of the aeration Basin. At that point (approximately elevation 2454.9), drop leg shall change to PVC. Provide 1/2-inch diameter stub 6 inches long with a 125-pound PVC flange on PVC portion of drop leg for diffuser gas cleaning system connection.
 - 4. In Aeration Basin 1 and Aeration Basin 2 use existing drop legs per design drawings.
- B. PVC Air Manifold:
 - 1. Perpendicular to air distribution headers, same nominal pipe size as drop leg See design drawings for manifold locations.
 - 2. Fabricate with minimum 4-inch-diameter fixed joint connections to each air distribution header. Fabricate Manifolds in sections up to 20 feet in length.
 - 3. Construct from Schedule 40 PVC. Manifolds shall be provided for long-term exposure to 130 degrees F near-wall temperature.

- C. Distribution Headers:
 - 1. Minimum 4-inch, maximum SDR 33.5 PVC.
 - 2. Fabricate in sections up to a maximum of 24 feet in length, with fixed joints or expansion joints as required.
 - 3. Fabricate with diffuser element holders factory solvent welded to crown of header. Attach diffuser elements to distribution headers to resist 150 foot-pounds applied torque about polar axis of holder and 100 foot-pounds about longitudinal axis. Equivalent alternate designs will be considered by Engineer.
- D. Include expansion/contraction system consisting of fixed or flanged joints and guide supports. Guide supports shall allow for longitudinal movement.

2.05 FLEXIBLE MEMBRANE DIFFUSER ASSEMBLIES

- A. Fine bubble, disk type with flexible perforated air release membrane. After 1 year of continuous operation without basin dewatering or diffuser cleaning, pressure drop through diffuser at specified flow rates shall not increase more than 1 psi.
- B. Backflow preventer assembly to prevent liquid from passing into aeration header. Diffusers shall require no special tools for attaching diffusers to diffuser connectors.
- C. Membrane: Ethylene propylene diene monomer (EPDM) suitable for application to continuous aeration of activated sludge mixed liquor without significant increase in head loss.
 - 1. Replaceable without use of any special tools.
 - 2. Exterior surface shall be smooth to restrict biological film growth.
 - 3. Inflate during aeration and deflate when airflow is discontinued, further restricting biological film growth.
 - 4. Cleanable in-place with water from a hose. Acid or other chemical cleaning methods shall not be required to restore diffuser to like-new performance conditions.
 - 5. Perforated over entire surface to release fine bubbles uniformly.
- D. Each Basin consists of four zones with a single header to Zone 2, Zone 3, and Zone 4 and two headers to FAZ, and Zone 1.
- E. Diffusers for the FAZ shall be flexible membrane diffuser.

2.06 CERAMIC DIFFUSER ASSEMBLIES

A. Circular Ceramic Diffuser Elements:

1. Composed of fused alumina oxide with a suitable ceramic bonding material.
2. Join individual alumina grains with a bonding material to form a strong, uniformly porous and homogeneous structure.
3. Free of loose or unbonded material, cracks, chips, spalling, or other structural defects. Diffuser elements shall be free of any material soluble in wastewater.
4. Uniform distribution of air bubble release across active surface (horizontal projected area) of diffuser element when submerged in water. Diffusers shall be nominal 9-inch diameter disc shaped diffuser.
5. Minimum Specific Permeability Rating of 26 scfm (plus or minus 20 percent).
6. Dynamic Wet Pressure (DWP) between 6.3 inches and 7.6 inches of water column in tap water.
7. Sufficient strength to support a hydrostatic load equivalent to 20 feet of water depth with a safety factor of four.

B. Each Basin consists of four zones with a single header to Zone 2, Zone 3, and Zone 4 and two headers to FAZ, and Zone 1.

C. Diffusers for Zone 1, Zone 2, Zone 3, and Zone 4 shall be ceramic diffuser.

D. PVC Diffuser Element Holders:

1. Air plenum chamber below diffuser element.
2. Mechanism to attach diffuser element to element holder.
3. Provide complete peripheral edge support for ceramic diffuser element.

E. Retaining Device:

1. Securely hold and seal ceramic diffuser element to element holder.
2. Diffuser assembly and retaining device shall prevent air escape at diffuser element-sealing gasket interface.
3. Gasket shall be on top of diffuser.
4. Vertical edges of diffuser elements shall not be exposed to liquid.
5. Sealing method shall allow applied sealing force between sealing gasket and ceramic element to be varied, with a minimum force of 50 pounds per inch of circumference of sealing gasket to provide a long-term positive seal and prevent air escape except through active area of diffuser element.
6. Retainer ring with a minimum of 2-1/2 complete threads with a minimum cross-section of 1/8 inch for engagement. Each diffuser element holder shall have an airflow control orifice.

2.07 SUPPORTS

- A. Supports for all the elements installed in the FAZ shall be designed to accommodate the forces generated by the submersible mixer installed in these zones.
- B. Fabricate from 0.250-inch minimum Type 304 stainless steelplate, ASTM A240/A240M. Use Type 304L stainless steel for welded parts, ASTM A240/A240M.
- C. Provide plus or minus 1/2-inch lateral and plus or minus 2-inch vertical adjustment of header. Adjustment shall be continuous and possible without removing air piping from support. Each air piping section shall have a minimum of two supports and additional supports as necessary to maintain level. Support height shall be sufficient to provide diffuser elevation shown on Drawings. Each support shall provide a bearing surface contoured to fit 360 degrees of air piping. Bearing surface shall be a minimum of 2 inches wide for manifolds and 1.5 inches wide for distribution headers.
- D. Air Manifold Piping Supports:
 - 1. Maximum spacing between supports of 8 feet.
 - 2. Resist thrust generated by expansion or contraction of air distribution headers.
 - 3. Include Manifold holddown, guide straps, anchor bolts, and supporting structure. Guide straps shall resist not less than 550 pounds uplift force per support without exceeding 24,000 psi design stress.
- E. Air Distribution Header (Guide) Supports:
 - 1. Maximum spacing between supports of 7 feet 6 inches.
 - 2. Allow longitudinal movement of header section to prevent stress buildup in header due to thermal expansion/contraction forces.
 - 3. Consist of self-limiting holddown and sliding mechanism. Sliding mechanism shall provide minimum resistance to movement of air Distribution Header under full buoyant uplift load. Mechanism shall provide 1/8-inch clearances around header and be self-limiting if mechanism is overtightened. Maximum horizontal thrust of 20 pounds or less shall initiate movement of header relative to mechanism under full buoyant uplift load.
- F. Support: Fixed, consisting of a holddown mechanism and self-limiting clamp device. Clamping shall positively grip air distribution header when tight and be self-limiting to prevent overstressing header if clamp is overtightened.

2.08 DRAINLINE, SUMP, AND AIRLIFT PURGE

- A. PVC System: To drain entire submerged aeration piping system. Each grid shall have an integral 4-inch diameter drainline terminating at a sump.
- B. Sump:
 - 1. Bottom elevation shall be lower than invert of air distribution headers and drainline.
 - 2. Connect to a 1-inch-diameter airlift eductor line extending from drainline invert elevation to a point approximately 5 feet above basin water level and terminate with a PVC ball valve.

2.09 DIFFUSER PRESSURE MONITORING SYSTEM

- A. Furnish each aeration grid with one pressure monitoring connecting box, bubbler tube, support brackets, polyethylene tubing and carrier pipe.
 - 1. Connecting Box: Handrail mounted fiberglass box capable of containing three 1/2-inch PVC ball valves, and quick coupling connectors, all of which are accessible through a front access door.
 - 2. Mounting Hardware: Type 316 stainless steel.
 - 3. Three ball valves connect to grid air distribution header and diffuser element holder plenum with 3/8-inch diameter tubing and a 1/2-inch bubbler tube (for submergence pressure at top of diffuser).
- B. Furnish one portable monitoring panel with at least one differential pressure gauge, quick coupling connectors, PVC ball valves, one set of calibration curves, and tubing and fittings as necessary to measure pressure differential between header and holder plenum and holder plenum and diffuser submergence.

2.10 HEADER JOINTS

- A. Special Flanged Joints or Slip Joints Between Sections of Air Distribution Header:
 - 1. Individual header sections shall rotate independently of adjacent header sections for alignment.
 - 2. Flanged Joints for Stainless Steel Piping: Face ring-follower flange type with through-bolts, capable of transmitting longitudinal forces caused by expansion and contraction in air distribution header.
 - 3. Slip joints shall allow for expansion and contraction of air distribution header.

- B. Fixed Joints for PVC Piping: Spigot section solvent welded to one end of Distribution Header, threaded socket section welded to mating distribution header, and O-ring gasket and threaded screw-on retainer ring.

2.11 APPURTENANCES

- A. Couplings: Van Stone type flanges ASTM A182/A182M stainless steel drilled 150-pound ASME B16.5 Standard.
- B. Face Rings: Stainless steel, ASTM A240/A240M, Type 304L, inside diameter (ID) drilled 1/16-inch larger than pipe outside diameter (OD).
- C. Gaskets: Neoprene, 45 durometer to 55 durometer; locate at expansion joints and couplings to form an airtight connection at 20 psig minimum.
- D. Miscellaneous: Nuts, bolts, washers, and other nonwelded parts: Type 304 stainless steel, ASTM A240/A240M. Threaded assemblies shall be chemically treated or lubricated prior to assembling to prevent galling.
- E. Lifting Lugs: Suitably attached for equipment assemblies and components weighing over 100 pounds.
- F. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.12 SOURCE QUALITY CONTROL

- A. Materials Testing:
 - 1. Test ceramic diffuser for DWP by submerging a diffuser at least 2 inches in tap water and operating at an air rate of 2 scfm per square foot plus or minus 10 percent.
 - 2. Test for strength by applying vertical load of 750 pounds to center 1-inch diameter of diffuser element when edges of element are supported by fixture similar to diffuser element holder.
- B. Factory Tests:
 - 1. Perform oxygen transfer tests on the aeration system for one aeration basin identical to that furnished.
 - 2. Oxygen Transfer Performance Testing Procedure: As described in most recent ASCE 2. Use a Theta value of 1.024. Engineer must approve specific details of test procedure and any deviation from requirements stated below.

- a. Nonsteady-state reaeration test shall consist of three reaeration test runs. SOTR shall be average of SOTRs obtained for each reaeration test run. Sodium sulfite catalyzed with cobalt chloride shall be used to strip residual dissolved oxygen between reaeration test runs.
 - b. Test Facilities: Provided by manufacturer and subject to approval of Engineer. Test facility shall be capable of providing sidewater depths and diffuser submergences specified under Article Service Conditions. Test aeration tank shall be a minimum of 200 square feet.
 - c. Diffuser density for each test shall be equal to or less than diffuser density proposed by manufacturer for aeration system being tested. Diffuser density is defined as number of diffusers per square foot of tank area.
 - d. For each system being tested, test airflow rate per diffuser (scfm per diffuser) shall not be greater than airflow rate per diffuser proposed for manufacturer's system.
3. Obtain approval of test reports from Engineer prior to fabrication or shipment of any equipment.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In accordance with manufacturer's written instructions.
- B. Accurately place anchor bolts using templates furnished by manufacturer and in accordance with Section 05 50 00, Metal Fabrications.

3.02 FIELD QUALITY CONTROL

- A. Functional Tests: Conduct on each aeration system.
- B. Performance Test:
 1. Conduct on each aeration system.
 2. Perform under actual or approved simulated operating conditions. Airflow shall be as measured by plant instrumentation. Calibrate airflow instrumentation as part of testing procedure.
 3. Test for a continuous 24-hour period without malfunction.
 4. Adjust, realign, or modify units and retest if necessary.
 5. Test as follows:
 - a. Pressure Test: Measure air pressure immediately upstream of elbow located at top of each drop leg, and at maximum airflows and submergences stated under Article Performance Requirements.

- b. Mixing Test:
 - 1) Perform at minimum airflows stated in Article Performance Requirements.
 - 2) Select three vertical lines and two depths in each basin.
 - 3) Take three Samples at each of two depths along each vertical line using Van Doren sampler.
 - 4) Independent testing laboratory approved by Engineer will perform residue test on each Sample. Mean value of total residue for three Samples at each depth will be used to determine conformance with requirements.
 - 5) All testing and sampling shall conform to procedures established in latest edition of Standard Methods for Examination of Water and Wastewater.

3.03 MANUFACTURER’S SERVICES

- A. Manufacturer’s Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
 - 1. 1 person-day for installation assistance and inspection.
 - 2. 1/2 person-day for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.
 - 3. 1/2 person-day for facility startup.
- B. See Section 01 43 33, Manufacturers’ Field Services.

END OF SECTION

VOLUME 4

DRAWINGS
(BOUND SEPARATELY)

VOLUME 5

**DESIGN DETAILS
(BOUND SEPARATELY)**



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