

TECHINICAL SPECIFICATIONS

FOR

City of Cleveland, Georgia

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**Wastewater Treatment Plant Expansion
Technical Specifications
Volume 2 of 2**

CITY OF CLEVELAND, GEORGIA

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SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

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

The project consists of electrical work in order to increase the overall treatment capacity of the existing facility as shown on the drawings. Major elements of the work include, but are not limited to the following:

 - 1. Provide, install, and test one (1) new 480/277V, 3Ph Panelboard (PP-2)
 - 2. Provide, install, and test one (1) new 125kW diesel Generator. Diesel generator shall include 24-hr rated sub-base fuel tank, weather protection enclosure, electrical connections for block heater and battery charger.
 - 3. Provide, install, and test various standalone adjustable frequency drives, Control Panels, Starters as shown on the drawings.
 - 4. Provide, install, and test various electrical components, such as dry-type transformers, panelboards, etc. as shown on the drawings.
 - 5. Provide all the required modification to existing electrical gears as noted on drawings to accommodate the plant expansion new loads.
 - 6. Provide and install new site lighting around process equipment as shown on the design drawings.
 - 7. Provide and install a complete electrical system to provide power to the new vendor supplied equipment associated with the plant expansion.

1.2 ACTION SUBMITTALS

- A. Provide Data For:
 - 1. Electrical service components.
 - 2. Internet service components.
 - 3. Nameplates, signs, and labels.
- B. Provide preliminary submittal for sequence of construction 14 days in advance of coordination meeting. Preliminary submittal shall include items listed in special project requirements.

1.3 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 (1,000 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).

1.4 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.

PART 2 - PRODUCTS

2.1 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 degrees F to 104 degrees F.
- C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the site ambient temperature range.

2.2 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, light gray color finish as approved by Owner.

2.3 NAMEPLATES

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

- D. Letter Height:
 - 1. Pushbuttons/Selector Switches: 1/8 inch.
 - 2. Other electrical equipment: 1/4 inch.

2.4 SIGNS AND LABELS

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

PART 3 - EXECUTION

3.1 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.

3.2 ANCHORING AND MOUNTING

- A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements.

3.3 COMBINING CIRCUITS INTO COMMON RACEWAY

- A. Homerun circuits shown on Drawings indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways in accordance with the following requirements:
 - 1. Analog control circuits from devices in same general area to same destination.
 - a. No power or AC discrete control circuits shall be combined in same conduit with analog circuits.
 - b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits shall be combined with power or Class 1 circuits.

- c. Analog circuits shall be continuous from source to destination. Do not add TJB, splice, or combine into a multi-pair cable without authorization of Engineer.
 - d. Raceways: shall be sized per General Circuit and Raceway Schedule and do not exceed 40 percent fill.
 - e. Changes shall be documented on Record Drawings.
- 2. Discrete control circuits from devices in the same general area to the same destination.
 - a. No power or analog control circuits shall be combined in same conduit with discrete circuits.
 - b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
 - c. Raceways shall be sized per the General Circuit and Raceway Schedule and do not exceed 40 percent fill.
 - d. Changes shall be documented on Record Drawings.
- 3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
 - a. Lighting Circuits: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
 - b. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits to a single raceway. Provide a separate neutral conductor for each circuit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
 - c. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.

3.4 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs:

- 1. Field mark Switchgear, switchboards, 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.
- 2. Use arc flash hazard boundary, energy level, PPE level and description, shock hazard, bolted fault current, and equipment name from study required in Section 26 05 70, Electrical Systems Analysis as basis for warning signs.

B. 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.

3.5 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.

3.6 CLEANING AND TOUCHUP PAINTING

- A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming. Includes all electrical gear and cabinets.
- 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.

3.7 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

1.1 SUMMARY

- A. This section includes basic materials and methods common to all sections of Division 26

1.2 ACTION SUBMITTALS

- A. Product Data For:
1. Control devices.
 2. Control relays.
 3. Circuit breakers.
 4. Fused switches.
 5. Nonfused switches.
 6. Timers.
 7. Fuses.
 8. Enclosures: Include enclosure data for products having enclosures.

1.3 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.

1.4 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 with Improved Formability and Ultra-High Strength.
 - c. E814 Standard Test Method for Fire Tests of Penetration Firestop Systems.
 2. Canadian Standards Association (CSA).
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
 4. Instrumentation, Systems, and Automation Society (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
- 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 Heavy Duty Enclosed and Dead-Front 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-Interruption.
 - h. 1059, Standard for Terminal Blocks.
 - i. 1479, Standard for Fire Tests of Penetration Firestops.

PART 2 - PRODUCTS

2.1 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

- A. General:
 - 1. Type: Molded case.
 - 2. Trip Ratings: 15-800 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.
 - 7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.

- D. Short Circuit Interrupting Ratings:
1. Equal to, or greater than, available fault current or interrupting rating shown.
 2. Equal to rating of existing equipment.
 3. Not less than the following RMS symmetrical currents for the indicated trip ratings:
 - a. Up to 100A, less than 250V ac: 14000 amps.
 - b. Up to 100A, 250-600V ac: 22,000 amps.
 - c. Over 100A: 65,000 amps.
 4. Series Connected Ratings: Do not apply series connected short circuit.
- E. 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.
- F. 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. 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.
- H. 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.
- I. 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.

2.2 DISCONNECT SWITCHES

- A. Disconnect Switches: UL-98 and NEMA KS-1; heavy duty, quick make, quick break type; horsepower and i2t rated. Provide lever type operating handle directly connected to the switch mechanism; rocker types are not acceptable. Include padlocking provisions and nameplate clearly indicating "ON" and "OFF" positions. Equip all switches with a ground lug and, where neutral conductors are scheduled, provide insulated neutral lugs.
- B. Fusible Switches: Equip with rejection clips for fuse types noted. Fuses shall be Class R, J, or L where required with 200,000A short circuit rating.
- C. Connections:

1. Mechanical lugs, except crimp compression lugs where shown.
 2. Lugs removable/replaceable.
 3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.
- D. Enclosures: As indicated on the drawings.
- E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.
- F. Acceptable Manufacturers: Eaton, General Electric/ABB, Square D or Siemens.
- G. Hazardous Areas: Where Division 1 or 2 classified areas are indicated, provide switches equal to Crouse-Hinds type FLS.

2.3 FUSES

- A. Fuses: Current limiting, non-renewable type, rated 200,000 AIC, with rejection feature; Class J or as required by load for ratings 600 amp and below and Class L for ratings 601 amp and above.
- B. Acceptable Manufacturers: Bussmann, Chase-Shawmut, or Littelfuse.

2.4 WIRING DEVICES

- A. Wall Switches: NEMA WD 1; FS W S 896; 20 amp, 120/277 volt, specification grade; horsepower rated; quiet type; back and side wiring provisions; toggle handle.
- B. Convenience Receptacles: NEMA WD 1; FS W C 596; 15 amp, 125 volt, specification grade; impact resistant nylon face; back and side wiring provisions; grounding screw. Where CR or NEMA 4X is indicated, provide corrosion resistant receptacle, yellow nylon body, one-piece brass contacts. Exception: Provide 5-20R receptacles for branch circuits serving one device.
- C. Specific Use Receptacles: NEMA WD 1 or WD 5; type as indicated. For branch circuits serving a single device, match device rating to branch circuit rating.
- D. Receptacle, Ground Fault Interrupter: Duplex, specification grade, tripping at 5-milliamps; 125-volt, configuration 5-20R.
- E. Device Colors: Gray, unless otherwise selected by the Architect for specific use devices.
- F. Indoor Device Plates: Type 302 stainless steel, 0.030 inch thick minimum, satin finish.
- G. Indoor Corrosion Resistant (NEMA 4X) Cover Plates: Type 302 stainless steel, specification grade, gasketed, with silicone rubber mat, equal to Pass & Seymour 4515 or 4515FS for toggle switches. Cast aluminum, gasketed, equal to Pass & Seymour CA Series receptacles. For devices which are continuously plugged in, provide cast aluminum, suitable for wet locations while-in-use, equal to Hubbell WP26.
- H. Outdoor Weatherproof (NEMA 3R and NEMA 4X) Cover Plates: Stainless steel, specification grade, gasketed equal to Sierra WP Series. For heat tape, instruments, or other devices which are

continuously plugged in, provide die cast aluminum, suitable for wet locations while in use, equal to Hubbell WP26.

2.5 INDIVIDUAL MOTOR STARTERS

- A. Manual Starters: NEMA ICS-2; general purpose type; trip-free mechanism; with overload relays. Provide pushbutton operation for integral horsepower sizes, and toggle switch or lever for fractional sizes.
- B. Magnetic Starters: NEMA ICS-2; NEMA size 1 minimum; magnetically held contactor with field replaceable coil and contacts; bimetallic or melting alloy overload relay, manually reset. Starter shall be rated in accordance with NEMA size designations; fractional sizes and ratings per IEC recommendations are not acceptable.
- C. Magnetic Starter Controls: All controls are 120 volts. Equip each starter with a control power transformer fused on the primary and secondary. Provide starter overload relay auxiliary contacts for red run light, green stop light and amber overload light on the enclosure door. Provide one spare normally open starter auxiliary contact, and door mounted start-stop pushbuttons or hand-off-auto selector switch as indicated.
- D. Combination Starters: Molded case circuit breaker rated 22,000 AIC as a minimum.
- E. Enclosure: As shown on the drawings.
- F. Acceptable Manufacturers: Allen-Bradley, Eaton, General Electric/ABB, Siemens or Square D.
- G. Hazardous Areas: Where Division 1 or 2 classified areas are indicated, provide starters equal to Crouse-Hinds types EPC, EMG, EMN, or EFS/EFD.

2.6 CONTACTORS

- A. Control Relays: NEMA A600; heavy duty, machine tool type convertible contacts; electrically held 120 volt coil. Equal to Allen-Bradley Bulletin 700 Type P.
- B. General Purpose Contactors: NEMA ICS-2; electrically held; 2-wire control; 120 volt coil. Size and number of contacts as indicated.
- C. Lighting Contactors: NEMA ICS-2; mechanically held; 3 wire control; 120 volt coil. Size and number of contacts as indicated.
- D. Enclosure: NEMA ICS-6; Type 1 unless otherwise noted.
- E. Acceptable Manufacturers: General Electric, Square D, ASCO, or Cutler-Hammer.

2.7 CONTROL STATIONS

- A. Pushbuttons, Selectors and Pilot Lights: 600 volt, heavy duty, factory sealed.

- B. Enclosure: Stainless steel meeting NEMA 4X and NEC Class I, Division 2, Group C and D requirements.
- C. Acceptable Manufacturers: Equal to Allen-Bradley Bulletin 800T.
- D. Hazardous Areas: Where Division 1 classified areas are indicated, provide control stations equal to Crouse-Hinds EFS/EFD series.

2.8 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. Nonmetallic Framing Channel:
 - 1. Material: Fire retardant, fiber reinforced vinyl ester resin.
 - 2. Channel fitting of same material as channel.
 - 3. Nuts and bolts of long glass fiber reinforced polyurethane.
- G. Manufacturers:
 - 1. B-Line Systems, Inc.
 - 2. Unistrut Corp.
 - 3. Aickinstrut.

2.9 ENCLOSURES

- A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrode position 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.

PART 3 - EXECUTION

3.1 GENERAL

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

3.2 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.

3.3 SUPPORT AND FRAMING CHANNEL

- A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.
- B. Channel Type:
 - 1. Interior, Wet or Dry (Noncorrosive) Locations:
 - a. Raceways: Carbon Steel (Hot-dip galvanized).
 - b. Conduits: Carbon Steel (Hot-dip galvanized).
 - c. Steel Raceway and Other Systems Not Covered: Carbon Steel (Hot-dip galvanized)..
 - 2. Interior, Corrosive (Wet or Dry) Locations:
 - a. Raceways: Stainless Steel.
 - b. Conduits: Stainless Steel.
 - c. PVC-Coated Steel Conduit and Other Systems Not Covered: Stainless Steel.
 - 3. Outdoor, Noncorrosive Locations:
 - a. Raceways: Carbon Steel (Hot-dip galvanized), except where mounted on aluminum handrail, then use aluminum framing channel.
 - b. Raceway and Other Systems Not Covered: Carbon Steel (Hot-dip galvanized).
 - 4. Outdoor Corrosive Locations:
 - a. Conduits: Stainless Steel.
 - b. Raceways: Stainless Steel.
 - c. PVC-Coated Steel Conduit and Other Systems Not Covered: Stainless Steel.
- C. Paint cut ends prior to installation with the following:
 - 1. Carbon Steel Channel: Zinc-rich primer.
 - 2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
 - 3. Nonmetallic Channel: Epoxy resin sealer.
 - 4. PVC-Coated Channel: PVC patch.

END OF SECTION

SECTION 26 05 05 CONDUCTORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes all cables and conductors to be used for the connection of equipment covered under section 26.

1.2 ACTION SUBMITTALS

- A. Wire and cable descriptive product information.
- B. Wire and cable accessories descriptive product information.

1.3 INFORMATIONAL SUBMITTALS

- A. Factory Test Report for conductors 600 volts and below.

1.4 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. Electronic Industries Alliance (EIA), Telecommunications Industry Association (TIA): TIA-568-B, Commercial Building Telecommunications Cabling Standard.
 - 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 Cables.
 - c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
 - 5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations 2.5 kV through 765 kV
 - b. 386, Separable Insulated Connector Systems for Power Distribution Systems Above 600V.

- c. 404, Standard for Extruded And Laminated Dielectric Shielded Cable Joints Rated 2,500 V to 500,000 V.
- 6. National Electrical Manufacturers' Association (NEMA):
 - a. CC 1, Electric Power Connectors for Substations.
 - b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables - ICEA S-73-532.
 - c. WC 70, Standard for Nonshielded Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
 - d. WC 71, Standard for Nonshielded Cables Rated 2,001-5,000 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.
- 7. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 262, Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- 8. Underwriters Laboratories Inc. (UL):
 - a. 13, Standard for Safety Power-Limited Circuit Cables.
 - b. 44, Standard for Safety Thermoset-Insulated Wires and Cables.
 - c. 62, Standard for Safety Flexible Cord and Cables.
 - d. 486A-486B, Wire Connectors.
 - e. 486C, Standard for Splicing Wire Connections.
 - f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - g. 854, Standard for Safety Service-Entrance Cables.
 - h. 1072, Standard for Safety Medium-Voltage Power Cables.
 - i. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - j. 1569, Metal Clad Cables.
 - k. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.5 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.
- B. Terminations and Splices for Conductors above 600 Volts: Work shall be done by Journeyman Lineman with splicing credentials.

PART 2 - PRODUCTS

2.1 CONDUCTORS 600V 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 THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.
- D. Flexible Cords and Cables:
 - 1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
 - 2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.2 600V RATED CABLE

- A. Building Wire:
 - 1. Thermoplastic Insulated Building Wire: NEMA WC-5.
 - 2. Cross linked polyethylene- insulated.
 - 3. Feeder and Branch Circuits: Single stranded conductor; 98% conductivity copper; 75/90°C; 600 volt PVC insulated with nylon jacket; type THWN/THHN. Minimum size #12 AWG.
 - 4. Feeder Conductors larger than 250 KCMIL; single stranded conductor copper; 90°C; 600 volt; flame retardant moisture resistant cross linked polyethylene insulated; type XHHW-2; minimum size 300 KCMIL.
 - 5. Control Circuits: Same as specified above for feeder and branch circuits, except minimum size #14 AWG.
- B. 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. Single or multi conductor construction.
 - 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 (in)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
9	0.83	60
25	1.00	60
37	1.15	80

- 4. Manufacturers:

- a. Okonite Co.
 - b. Southwire
- C. 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 crosslinked 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 (in)	Nominal Jacket Thickness (Mils)
12	12	2	0.42	45
		3	0.45	45
		4	0.49	45
10	10	2	0.54	60
		3	0.58	60
		4	0.63	60
8	10	3	0.66	60
		4	0.75	60
6	8	3	0.74	60
		4	0.88	60
4	6	3	0.88	60
		4	1.04	80
2	6	3	1.01	80
		4	1.16	80
1	6	3	1.10	80
		4	1.25	80
1/0	6	3	1.22	80
		4	1.35	80
2/0	4	3	1.32	80
		4	1.53	80
3/0	4	3	1.40	80
		4	1.60	80
4/0	4	3	1.56	80
		4	1.78	110

5. Manufacturers:

- a. Okonite Co.
- b. Southwire

- D. 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, 600VAC rated.
 - 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. 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, 600VAC rated.
 - 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.
- F. 18 AWG, Multi-Twisted, Shielded Pairs with a Common, Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.
1. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
 - b. Tinned copper drain wires.
 - c. Pair drain wire size AWG 20, group drain wire size AWG 18.
 - d. Insulation: 15-mil PVC, 600VAC rated.
 - e. Jacket: 4-mil nylon.
 - f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
 - g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
 2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
 3. Cable Sizes:

Number of Pairs	Max. Outside Diameter (in)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

4. Manufacturers

- a. Okonite Co.
- b. Alpha Wire Co.
- c. Belden

G. Multi-Conductor Adjustable Frequency Drive (AFD and VFD) Power Cable:

1. Conductors:
 - a. Class B, stranded coated copper.
 - b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
 - c. Grounding Conductors: Insulated stranded copper.
2. Sheath:
 - a. UL 1277 Type TC, 90 degrees C.
 - b. Continuous shield, Al/polyester foil, drain wires, overall copper braid.
3. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
4. Cable Sizes:

Conductor Size (AWG)	Minimum Ground Wire size (AWG)	No. Of Insulated Conductors	Max Outside Diameter (in)	Jacket Thickness (Mils)
12	12	4	0.610	50
10	10	4	0.670	50
8	8	4	0.910	50
6	6	4	1.010	50
4	4	4	1.150	50
2	2	4	1.310	50

5. Manufacturers and Products:

- a. Belden, Series 29500.
- b. Alpha Wire, Series V.
- c. LAPP USA, OLFLEX VFD Slim.

2.3 SPECIAL CABLES

A. 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-B.2-1 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.

B. Data Highway Cable, Allen-Bradley "Blue Hose."

1. Meet or exceed electrical characteristics of Allen-Bradley Catalog No. 1770-CD.
2. Approved by Allen-Bradley for use with A-B programmable logic controller systems.
3. Outer Jacket: Blue PVC.
4. Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
5. Drain: 55 percent tinned copper braid and drain wire.
6. Dimension: 0.243-inch nominal OD.
7. Conductors:
 - a. One pair #20 AWG, seven-strand tinned copper.
 - b. Insulation: Polyethylene.
 - c. Color Code: Blue and clear.
8. Manufacturers:
 - a. Allen-Bradley.
 - b. Belden.

C. DeviceNet Round Cable, 600V, Class 1, Two Twisted, Shielded Pairs with a Common Overall Shield:

1. Outer Jacket: PVC.
2. Overall Shield: Tinned copper braid, 18 AWG tinned copper drain wire.
3. Individual Pair Shield: Aluminum foil-polyester tape.
4. Dimension: 0.460-inch nominal OD.
5. Conductors:
 - a. 15 AWG stranded tinned copper.
 - b. Insulation: FEP.
6. Manufacturer and Product: Belden; 7897A.

D. DeviceNet Flat Cable, 600V, Class 1, Four Conductor Unshielded Network Trunk Cable:

1. Outer Jacket: Thermoplastic Elastomer (TPE).
2. Conductors: Four conductor, unshielded, flat configuration.
3. Manufacturer and Product: Allen-Bradley; 1485C-P1E.

E. Fiber Optic Cable

1. Fiber optic cable shall be optic multimode, loose tube, all-dielectric cable, Siemens, Nordx/CDT, Belden, or approved equal, and meet the following specifications:

Cladding Diameter

125.0 Microns

Core Diameter	62.5 Microns
Attenuation Range	≤0.8 dB/KM at 1300 NM ≤3.1 dB/KM at 850 NM
Bandwidth Range	≥600 Mhz-KM at 1300 NM ≥200 Mhz at 850 NM
Cable Construction	Splitable outdoor cable
Core Type	Hollow core, filled
Materials	
– basic element	PVC, gray
– strain relief	Kevlar fibers and impregnated glass
– outer sheath/cable color	PVC black
Mechanical Characteristics	
– dimensions of basic element	(3.5 ± 0.2) mm dia
– cable dimensions	(6.3 X 9.8) ± 0.4 mm
– cable weight	aprox. 65 kg/km
– permissible tensile load	≤ 500 N (short time)
– bending radii	≥ 100 mm Over flat side only
Permissible Ambient Conditions	
– laying and installation temp.	-5°C to +50°C
– operating temperature	-25°C to +60°C
– storage temperature	-25°C to +70°C

Cable shall be compliant with EIA, ANSI Standards, graded index. All fibers must be color coded for easy identification with all-dielectric construction. All cables shall be of an insulation type rated for the purpose of installation. Where shown on Contract Drawings all fiber optic conduit run shall contain redundant 24 strand fiber optic cables as specified in this section.

2. Connector Type BFOC.
3. Coordinate the exact fiber cable requirement with the SCADA system integrator.

2.4 GROUNDING CONDUCTORS

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

2.5 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.

G. Data Cable Accessories: Terminators, connectors, and junctions necessary for a complete DeviceNet system.

2.6 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.

2.7 WARNING TAPE

- A. As specified in Section 26 05 33, Raceways and Boxes.

2.8 SOURCE QUALITY CONTROL

- A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.
- B. Conductors Above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 6 partial discharge level test for EPR insulated cable.

PART 3 - EXECUTION

3.1 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 all 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-centerspacing 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.

3.2 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 an 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
240/120v 1Ph, 3W	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208/120v 3Ph, 4W	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120v 3Ph, 4W Delta, Center Tap Ground on 1Ph	Grounded Neutral Phase A High (Wild) Leg Phase C	White Black Orange Blue
240/120v 1Ph, 3W	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
480/277v 3Ph, 4W	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 an identifiable colored strip, other than green, in accordance with NFPA 70.
- B. Conductors Above 600 Volts: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 inches to 2 inches wide.
1. Colors:
 - a. Grounded Neutral: White.
 - b. Phase A: Brown.
 - c. Phase B: Orange.
 - d. Phase C: Yellow.

3.3 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 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.

C. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 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.

3.4 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 all 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, braid 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. Cable Protection:
 - a. Under Infinite Access Floors: May install without bundling.
 - b. 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.
 - c. Maintain integrity of shielding of instrumentation cables.
 - d. Ensure grounds do not occur because of damage to jacket over the 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.

3.5 CONDUCTOR ARC AND FIREPROOFING

- A. Install arc and fireproofing tape on 5 kV cables throughout their entire exposed length in manholes, handholes, vaults, cable trays, and other indicated locations.
- B. Wrap conductors of same circuit entering from separate conduit together as a single cable.
- C. Follow tape manufacturer's installation instructions.
- D. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

3.6 UNDERGROUND DIRECT BURIAL CABLE

- A. Warning Tape: Install approximately 3 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.
 - 3. Foundation steel electrodes.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
 - 1. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
 - a. Test wells.
 - b. Ground rods.
 - c. Ground rings.
 - d. Grounding arrangements and connections for separately derived systems.
 - 2. Instructions for periodic testing and inspection of grounding features at test wells and ground rings.
 - a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.

- b. Include recommended testing intervals.

1.5 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).

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.3 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.
- E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- H. Conduit Hubs: Mechanical type, terminal with threaded hub.
- I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- K. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.
- L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- N. Straps: Solid copper, copper lugs. Rated for 600 A.
- O. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.
- P. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- Q. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with stainless-steel bolts.
 - a. Material: Tin-plated aluminum.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet
- B. Ground Plates: 1/4 inch thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches below grade.
- C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.

- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Armored and metal-clad cable runs.
 - 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - 9. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

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

3.6 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Grounding shall be connected back to the grounding grid at the pumping station.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- E. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections as required.
- B. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Grounding system shall be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 3. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
 - 4. Manhole Grounds: 10 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

C. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M.
 - 2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame Rating: Class 1.
 - 2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
 - 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 2. Material for Channel, Fittings, and Accessories: Stainless steel, Type 304.
 - 3. Channel Width: Selected for applicable load criteria.
 - 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Stainless Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 6. Toggle Bolts: Stainless-steel springhead type.
 - 7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 - 1. NECA 1.
 - 2. NECA 101
 - 3. NECA 102.
 - 4. NECA 105.
 - 5. NECA 111.
- B. Comply with all applicable Codes' requirements for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit.
- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, RMC may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

END OF SECTION

SECTION 26 05 33
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Metal wireways and auxiliary gutters.
 - 4. Nonmetal wireways and auxiliary gutters.
 - 5. Surface raceways.
 - 6. Boxes, enclosures, and cabinets.
 - 7. Handholes and boxes for exterior underground cabling.
- B. Related Requirements:
 - 1. Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of conduit groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1.4 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, Sixteenth Edition.
 - 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, Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
3. Electronic Industry Alliance (EIA) and Telecommunications Industry Association (TIA): 569, Commercial Building Standard for Telecommunications Pathways and Spaces.
4. National Electrical Contractor's Association, Inc. (NECA):
 - a. 101, Standard for Installing Steel Conduit (Rigid, IMC, EMT).
 - b. 102, Standard for Installing Aluminum Conduits.
 - c. 105, Recommended Practice for Installing Metal Cable Trays.
 - d. 111, Standard for Installing Nonmetallic Raceway (RNC, ENT, LFNC).
5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. C80.1, Specification for Rigid Steel Conduit, Zinc Coated.
 - c. C80.3, Specification for Electrical Metallic Tubing, Zinc Coated.
 - d. C80.5, Specification for Rigid Aluminum Conduit.
 - e. C80.6, Intermediate Metal Conduit (IMC) – Zinc Coated.
 - f. RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - g. TC 2, Electrical Polyvinyl Chloride (PVC) Plastic Tubing and Conduit.
 - h. TC 3, Polyvinyl-Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - i. TC 6, 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 Flexible Metal Conduit.
 - b. 5, Standard for Surface Metal Raceways and Fittings
 - c. 6, Standard for Electrical Rigid Metal Conduit – Steel.
 - d. 6A, Standard for Electrical Rigid Metal Conduit – Aluminum, Bronze, and Stainless.
 - e. 50, Standard for Enclosures for Electrical Equipment.
 - f. 360, Standard for Liquid-Tight Flexible Steel Conduit.
 - g. 514B, Standard for Conduit, Tubing, and Cable Fittings.
 - h. 514C, Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
 - i. 651, Standard for Schedule 40 and 80 Rigid PVC Conduit.
 - j. 651A, Standard for Type EB and A Rigid PVC Conduit and HDPE Conduit.
 - k. 797, Standard for Electrical Metallic Tubing.
 - l. 870, Standard for Wireways, Auxiliary Gutters, and Associated Fittings.
 - m. 1242, Standard for Intermediate Metal Conduit.
 - n. 1660, Standard for Liquid-Tight Flexible Nonmetallic Conduit.
 - o. 1684, Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

- p. Standard for Optical Fiber and Communication Cable Raceway.

1.5 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.
 - 3. PVC-Coated, Rigid Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 - PRODUCTS

2.1 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. Aluminum Rigid Conduit:
 - 1. Meet requirements of UL 6; ANSI C80.1.
 - 2. Material: aluminum; minimum size 3/4-inch.
- C. 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.
- D. Electric Metallic Tubing (EMT):
 - 1. Meet requirements of NEMA C80.3 and UL 797.
 - 2. Material: Hot-dip galvanized with chromated and lacquered protective layer.
- E. 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.
- F. PVC tubing (Type EB):
 - 1. Meet requirements of NEMA TC 6 and UL 651A.
 - 2. UL listed for reinforced concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.
- G. 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 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.
- H. Flexible Metal, Liquid-Tight Conduit:
 - 1. UL 360 listed for 105 degrees C insulated conductors.
 - 2. Material: Galvanized steel with extruded PVC jacket.
- I. Flexible Metal, Nonliquid-Tight Conduit:
 - 1. Meet requirements of UL 1.
 - 2. Material: Galvanized steel.
- J. Flexible, Nonmetallic, Liquid-Tight Conduit:
 - 1. Material: PVC core with fused flexible PVC jacket
 - 2. UL 1660 listed for:
 - a. Dry Conditions: 80 degrees C insulated conductors.
 - b. Wet Conditions: 60 degrees C insulated conductors.
 - 3. Manufacturers and Products.
 - a. Carlon; Carflex or X-Flex.
 - b. T & B; Xtraflex LTC or EFC.
- K. Innerduct:
 - 1. Resistant to spread of fire, per requirements of UL 2024.
 - 2. Smooth or corrugated HDPE.
 - 3. Textile Manufacturer Maxcell.

2.2 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-1.
 - 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 BU-1.
 - 2) O-Z/Gedney; Type HBLG.
 - 4. Conduit Hub:
 - a. Material: Malleable iron with integral 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 Condition):
 - 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: Assupplied 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.
 - 3) Killark; Series O electrolets.
 - 4) Thomas & Betts; Form 7 or Form 8.
- 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; Type 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. Electric Metallic Tubing:

1. Meet requirements of UL514B.
2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
3. Electro zinc-plated inside and out.
4. Raintight.
5. Coupling Manufacturers and Products:
 - a. Appleton; Type 95T.
 - b. Crouse-Hinds.
 - c. Thomas & Betts.
6. Connector Manufacturers and Products:
 - a. Appleton; Type ETP.
 - b. Crouse-Hinds.
 - c. Thomas & Betts.

C. PVC Conduit and Tubing:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

D. 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.

E. 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.

F. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Body: Galvanized steel or malleable iron.
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. Manufacturers and Products: Appleton; Series 7400.

- G. Flexible, Nonmetallic, Liquid-Tight Conduit:
 - 1. Meet requirements of UL 514B.
 - 2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferule, sealing ring, and compression nut.
 - 3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
 - 4. Manufacturers and Products:
 - a. Carlon; Type LT.
 - b. Thomas & Betts; Series 6300.
 - c. O-Z/Gedney; Series 4Q-P.
- H. Flexible Coupling, Hazardous Locations:
 - 1. Approved for use in atmosphere involved.
 - 2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
 - 3. Outer bronze braid and an insulated liner.
 - 4. Conductivity equal to a similar length of rigid metal conduit.
 - 5. Manufacturers and Products:
 - a. Crouse-Hinds; Type ECGJH or Type ECLK.
 - b. Appleton; EXGJH or EXLK.
- I. 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.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 12 unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

- C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- H. Gangable boxes are prohibited.
- I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- J. Cabinets:
 - 1. NEMA 250, Type 4X stainless steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.

2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Standard: Comply with SCTE 77.
 2. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC".
 6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: Galvanized Rigid Steel (non corrosive areas) and PVC Coated GRS (corrosive areas).
 2. Concealed Conduit, Aboveground: IMC (non corrosive areas).
 3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 5. Boxes and Enclosures, Aboveground: as indicated on the drawings.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated.
1. Exposed, Not Subject to Physical Damage: Galvanized Rigid Steel (non corrosive areas) and PVC Coated GRS (corrosive areas).
 2. Exposed, Not Subject to Severe Physical Damage: Galvanized Rigid Steel (non corrosive areas) and PVC Coated GRS (corrosive areas).
 3. Exposed and Subject to Severe Physical Damage: Galvanized Rigid Steel (non corrosive areas) and PVC Coated GRS (corrosive areas):
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 4. Concealed in Ceilings and Interior Walls and Partitions: IMC (non corrosive areas).
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Damp or Wet Locations: Galvanized Rigid Steel (non corrosive areas) and PVC Coated GRS (corrosive areas).
 7. Boxes and Enclosures: as indicated on the drawings.
- C. Minimum Raceway Size: 3/4-inch (21-mm) trade size above grade and 1" underground.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface raceways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.
- D. Do not fasten conduits onto the bottom side of a metal deck roof.
- E. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- F. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- G. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
- J. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- K. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- L. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 3. Arrange raceways to keep a minimum of 2 inches (50 mm) of concrete cover in all directions.
 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 5. Change from RNC to GRC before rising above floor.
- M. Stub-ups to Above Recessed Ceilings:
1. Use EMT, IMC, or RMC for raceways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- Q. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35-mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- S. Surface Raceways:
1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.
- U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where an underground service raceway enters a building or structure.
 3. Conduit extending from interior to exterior of building.
 4. Conduit extending into pressurized duct and equipment.
 5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 6. Where otherwise required by NFPA 70.
- V. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m).
 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per degree F (0.06 mm per meter of length of straight run per degree C) of temperature change for PVC conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- W. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 36 inches (915 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors. Flexible conduit shall be type UA Sealtite with copper bands or engineer approved equal.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to bottom of box unless otherwise indicated.
- Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.
- Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- AA. Locate boxes so that cover or plate will not span different building finishes.

- BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- DD. Set metal floor boxes level and flush with finished floor surface.
- EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
 2. Install backfill as specified in Section 312000 "Earth Moving."
 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
 4. Install manufactured duct elbows for stub-up at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
 5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
 6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install handholes with bottom below frost line below grade.
- E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies.

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including GRC conduit.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Precast concrete handholes.
6. Polymer concrete handholes and boxes with polymer concrete cover.
7. Fiberglass handholes and boxes with polymer concrete cover.
8. Fiberglass handholes and boxes.
9. High density plastic boxes.

1.2 DEFINITIONS

- A. Direct Buried:** Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct:** A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:**
1. Two or more ducts installed in parallel, with or without additional casing materials.
 2. Multiple duct banks.

1.3 ACTION SUBMITTALS

- A. Product Data:** For each type of product.
- B. Shop Drawings:**
1. **Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:**
 - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include cover design.
 - d. Include grounding details.
 - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.4 INFORMATIONAL SUBMITTALS

- A. Duct and Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- C. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

- A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
- C. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 DUCT ACCESSORIES

- A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.4 MANHOLE AND HANDHOLE CONSTRUCTION MATERIALS

A. Manholes:

1. Concrete: Where applicable, conform to Division 03 - Cast-In-Place Concrete, for concrete and reinforcing.
 - a. Strength: 3000 psi (20.7 Mpa) minimum 28-day compressive strength.
 - b. Aggregate for Duct Encasement: 3/8-inch maximum size.
2. Concrete Reinforcement: All underground structures, including duct banks, shall utilize concrete reinforced with rebar. Intent is for rebar details to be in accordance with the requirements of Division 03 – Concrete Reinforcement and Dowelling, and / or electrical details as shown on the Contract Drawings. In the details in Contract Drawings, structure and duct bank rebar shall be #4 steel rebar. Install rebar continuously near all the structure's or duct bank's top and bottom edges and corners, with additional #4 rebar spaced such that maximum spacing between rebars is 18-inches. Additionally, duct banks shall have #4 rebar placed across the top and bottom of the bank, every 18-inches, for the entire length of the duct bank.

B. Handholes:

1. Non Traffic Areas:
 - a. Box: Polymer concrete from select-grade aggregates reinforced with fiber-glass in combination with a polymer resin system.
 - b. Cover: Polymer concrete type with locking bolts and pull slots
 - c. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
 - d. Size: Minimum size shall be 10" x 17" and Maximum size shall be 30" x 48". When larger enclosure is required, manhole construction shall be used.
2. Traffic Areas:
 - a. Box: Reinforced, cast concrete with extension and bottom slab.
 - b. Cover: Steel checked plate; H/20 loading with screw down.
 - c. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.

2.5 MANHOLES AND HANDHOLES ACCESSORIES

- A. Cable racks, supports, pulling-in-irons, and hardware shall be hot dipped galvanized steel.
- B. Precast concrete manholes and handholes shall be heavy duty type, designed for a Class H20 wheel load. Precast manholes and handholes shall be as manufactured by Old Castle Precast, Inc., or approved equal.
- C. Manhole frames and covers shall be cast-iron heavy-duty type for class H-20-wheel loading, and shall be as manufactured by Neenah, or equal. Manhole covers shall be marked Electrical Medium Voltage or Electric Low Voltage as applicable, in addition stamp the manhole covers with minimum 1-1/2-inch high letters and numbers for manhole identifi-

cation. Provide gasketed covers with stainless steel non-standard bolt head configuration security bolts. Provide two (2) special 1/2-inch drive sockets to fit the security bolts supplied. Apply anti-siege compound to the security bolts prior to installation. The minimum manhole cover diameter shall be 26”.

- D. Handhole covers and frames shall be hot dipped galvanized and designed for a Class H-20-wheel load. Handhole covers and hatches shall have Type 316 stainless steel security bolts. Handhole covers shall be marked Electric Medium Voltage or Electric Low Voltage as applicable, in addition stamp the handhole covers with minimum 1-1/2-inch high letters and numbers for handhole identification. Provide gasketed covers with stainless steel non-standard bolt head configuration security bolts. Provide two (2) special 1/2-inch drive sockets to fit the security bolts supplied. Apply anti-siege compound to the security bolts prior to installation.
- E. Conduit bell ends shall be installed in all manholes.
- F. Manholes and Handholes shall be installed to permit passive drainage of infiltration seepage as detailed on the Drawings. In the absence of such detail, provide 3-inch diameter PVC sleeve at low point of structure extending to a depth approximately 12-inches below the bottom surface of the structure. Provide a finely crushed and packed stone base below the structure to a total depth approximately 24-inches below the structure bottom to permit drainage. Provide drain cover at pipe termination in structure.

2.6 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by an independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities,

underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to handholes, and as approved by Architect.

3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical Feeders 600 V and Less: RNC Type EPC-40-PVC, direct-buried unless otherwise indicated.
- B. Duct for Electrical Branch Circuits: RNC Type EPC-40-PVC, direct-buried unless otherwise indicated.
- C. Underground Ducts Crossing Paved Paths, Driveways and Roadways: RNC Type EPC-40 PVC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
 - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
 - 4. Cover design load shall not exceed the design load of the handhole or box.

3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area immediately after backfilling is completed or after construction vehicle traffic in immediate area is complete.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching.
- E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures.

3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward handholes and away from buildings and equipment. Slope duct from a high point between two handholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.
 - 1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. End Bell Entrances to Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.
- H. Terminator Entrances to Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.
- I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls.
- J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- K. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.
- L. Direct-Buried Duct and Duct Bank:
 - 1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
 - 2. Width: Excavate trench 12 inches wider than duct on each side.

3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
8. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
 - a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.
 - b. Place minimum 6 inches of engineered fill above concrete encasement of duct.

- M. Underground-Line Warning Tape: Bury magnetic underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches above all duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of ductbank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

- D. Install handholes and boxes with bottom below frost line.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000 psi, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
 - 2. Dimensions: 12 inches wide by 12 inches deep.

3.7 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
 - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
 - 3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

3.9 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of handholes, including sump.

1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

END OF SECTION 260543

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Color and legend requirements for raceways, conductors, and warning labels and signs.
- 2. Labels.
- 3. Bands and tubes.
- 4. Tapes and stencils.
- 5. Tags.
- 6. Signs.
- 7. Cable ties.
- 8. Paint for identification.
- 9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.

- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.
 - 1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
 - 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - 3. Colors for 240-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - 4. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - 5. Color for Neutral: White.
 - 6. Color for Equipment Grounds: Green.
 - 7. Colors for Isolated Grounds: Green with white stripe.
- C. Warning Label Colors:
 - 1. Identify system voltage with black letters on an orange background.
- D. Warning labels and signs shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

E. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
- B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameter and that stay in place by gripping action.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, polyester flexible label with acrylic pressure-sensitive adhesive.
 1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
 2. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
 1. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches for raceway and conductors.
 - b. 3-1/2 by 5 inches for equipment.
 - c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

- A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameter and that stay in place by gripping action.
- B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around item being identified. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

2.5 TAPES AND STENCILS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

- C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and is 12 inches wide. Stop stripes at legends.
- D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
- E. Underground-Line Warning Tape:
 - 1. Tape:
 - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical utility lines.
 - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 - 2. Color and Printing:
 - a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
 - c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
 - 3. Tag: Type I:
 - a. Pigmented polyolefin, bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Thickness: 4 mils.
 - d. Weight: 18.5 lb/1000 sq. ft.
 - e. Tensile according to ASTM D 882: 30 lbf and 2500 psi.
 - 4. Tag: Type ID:
 - a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Overall Thickness: 5 mils.
 - d. Foil Core Thickness: 0.35 mil.
 - e. Weight: 28 lb/1000 sq. ft.
 - f. Tensile according to ASTM D 882: 70 lbf and 4600 psi.
- F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 TAGS

- A. Write-on Tags:
 - 1. Polyester Tags: 0.010-inch-thick, with corrosion-resistant grommet and cable tie for attachment.
 - 2. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black, except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black.
- C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F.
 - 5. Color: Black.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.
- H. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- I. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "EMERGENCY POWER."
 - 2. "POWER."
 - 3. "UPS."
- M. Vinyl Wraparound Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
- O. Self-Adhesive Wraparound Labels: Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
- P. Self-Adhesive Labels:
1. On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
- Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.
- S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
- T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- U. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- V. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.
- W. Underground Line Warning Tape:
1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
 2. Limit use of underground-line warning tape to direct-buried cables.
 3. Install underground-line warning tape for direct-buried cables and cables in raceways.
- X. Write-on Tags:
1. Place in a location with high visibility and accessibility.
 2. Secure using corrosion resistant cable ties.

Y. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

Z. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

AA. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

BB. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.
 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
 1. "POWER"
 2. "CONTROLS"

3. "SIGNALS"

- E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels with the conductor or cable designation, origin, and destination.
- G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.
- H. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- I. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
- J. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- K. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
- L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive equipment labels.
 - 1. Apply to exterior of door, cover, or other access.
 - 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
- M. Equipment Identification Labels:
 - 1. Indoor Equipment: self-adhesive label.
 - 2. Outdoor Equipment: Laminated acrylic or melamine sign.

END OF SECTION

SECTION 26 05 72
OVERCURRENT PROTECTIVE DEVICE SHORT CIRCUIT STUDY

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices. The extents of the study shall include the all the electrical equipment associated with the new power distribution system.

1.2 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - 1. Short-circuit study input data, including completed computer program input data sheets.
 - 2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
 - b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: the study shall be performed by the firm regularly engaged in plant power system studies and analysis with at least 5 years of relevant experience.
- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.4 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

- A. Comply with IEEE 399 and IEEE 551.
- B. Analytical features of fault-current-study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 1. Protective device designations and ampere ratings.
 2. Cable size and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Comments and recommendations for system improvements, where needed.
- E. Protective Device Evaluation:
 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.
- G. Short-Circuit Study Output:
1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
 3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Obtain all data necessary for the conduct of the study.
1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.

2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate the following input data to support the short-circuit study:
1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Obtain electrical power utility impedance at the service.
 3. Power sources and ties.
 4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
 7. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
 8. Motor horsepower and NEMA MG 1 code letter designation.
 9. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system study shall include the entire facility.
- E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. The calculations shall include the ac fault-current decay from induction motors. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:

1. Electric utility's supply termination point.
2. Incoming switchgear.
3. Low-voltage switchgear.
4. Motor-control centers.
5. Control panels.
6. Automatic transfer switches.
7. Branch circuit panelboards.
8. Disconnect switches.

3.3 ADJUSTING

- A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.4 DEMONSTRATION

- A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION

SECTION 260573
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping. The extents of the study shall include the all the electrical equipment associated with the new power distribution system.

1.2 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - 1. Coordination-study input data, including completed computer program input data sheets.
 - 2. Study and equipment evaluation reports.
 - 3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: the study shall be performed by firm regularly engaged in plant power system studies and analysis with at least of 5 years of relevant experience.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. The following parts from the Protective Device Coordination Study Report:

- 1) One-line diagram.
- 2) Protective device coordination study.
- 3) Time-current coordination curves.

b. Power system data.

1.5 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Comply with IEEE 242 and IEEE 399.
- B. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary.

- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
- F. Protective Device Coordination Study:
 - 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
 - b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.
- G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - 1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
 - 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
 - 3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - d. Transformer full-load current, magnetizing inrush current.
 - e. Ground-fault protective devices.
 - f. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. The study shall be based on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system study shall include the entire facility.
- E. Begin analysis at the service, extending down to the system overcurrent protective devices.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. The calculations shall include the ac fault-current decay from induction motors. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
1. Electric utility's supply termination point.
 2. Switchgear.
 3. Low-voltage switchgear.
 4. Motor-control centers.
 5. Standby generators and automatic transfer switches.
 6. Branch circuit panelboards.
- I. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the overcurrent protective device study.
1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
 2. Use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate the following input data to support coordination study. The list below is a guide.
1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Electrical power utility impedance at the service.
 3. Power sources and ties.
 4. Short-circuit current at each system bus, three phase and line-to-ground.
 5. Full-load current of all loads.
 6. Voltage level at each bus.
 7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 8. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
 9. Maximum demands from service meters.
 10. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
 11. Motor horsepower and NEMA MG 1 code letter designation.

12. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
13. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Ratings, types, and settings of utility company's overcurrent protective devices.
 - c. Special overcurrent protective device settings or types stipulated by utility company.
 - d. Time-current-characteristic curves of devices indicated to be coordinated.
 - e. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - f. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - g. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

3.4 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.5 DEMONSTRATION

- A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:
 1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
 2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
 3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 260573

SECTION 26 05 74
OVERCURRENT PROTECTIVE DEVICE ARC FLASH STUDY

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment. The extents of the study shall include the all the electrical equipment associated with the new power distribution system.

1.2 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals **shall** be in digital form.
 - 1. Arc-flash study input data, including completed computer program input data sheets.
 - 2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: the study shall be performed by the firm regularly engaged in plant power system studies and analysis with at least 5 years of relevant experience.
- B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:
 - 1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
 - 2. Operation and Maintenance Procedures: Provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.5 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 SOFTWARE DEVELOPERS

- A. Comply with IEEE 1584 and NFPA 70E.
- B. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.

- E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
- F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."
- G. Arc-Flash Study Output:
 - 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- H. Incident Energy and Flash Protection Boundary Calculations:
 - 1. Arcing fault magnitude.
 - 2. Protective device clearing time.
 - 3. Duration of arc.
 - 4. Arc-flash boundary.
 - 5. Working distance.
 - 6. Incident energy.
 - 7. Hazard risk category.
 - 8. Recommendations for arc-flash energy reduction.
- I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies:

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
 2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."
- C. Calculate maximum and minimum contributions of fault-current size.
1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- E. Include low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
- F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:
1. Fault contribution from induction motors should not be considered beyond three to five cycles.
- H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
1. When the circuit breaker is in a separate enclosure.
 2. When the line terminals of the circuit breaker are separate from the work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.
- 3.3 POWER SYSTEM DATA
- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of the Engineer.
 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
5. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
6. Motor horsepower and NEMA MG 1 code letter designation.
7. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.4 DEMONSTRATION

- A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Requirements specified within this section apply to the commissioning of electrical systems.
- B. Safety: Ensure work areas are restricted to any non-authorized commissioning professionals. Areas undergoing commissioning shall be taped off and indicated as restricted areas.
- C. Sequencing and scheduling:
 - 1. Perform inspection and electrical tests after equipment here in listed has been installed.
 - 2. Perform tests with apparatus de-energized whenever feasible.
 - 3. Inspection and electrical tests on energized equipment shall be:
 - a. Scheduled with Engineer and Owner prior to de-energization.
 - b. Minimized to avoid extended period of interruption to the operating plant equipment.
 - 4. Notify Engineer and Owner at least 24 hours prior to performing tests on energized electrical equipment.

1.2 INFORMATIONAL SUBMITTALS

- A. Provide the following:
 - 1. Submit 30 days prior to performing inspections or tests:
 - a. Schedule for performing inspection and tests.
 - b. List of references to be used for each test.
 - c. Sample copy of equipment and materials inspection form(s).
 - d. Sample copy of individual device test form.
 - e. Sample copy of individual system test form.
 - 2. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
 - 3. Operation and Maintenance Data:
 - a. In accordance with Division 01, General Requirements.
 - 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.

1.3 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM):
 - a. D665, Standard Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
 - b. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - c. D923, Standard Practices for Sampling Electrical Insulating Liquids.

- d. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
- e. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
- f. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
- g. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
- h. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
- i. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
- j. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
- k. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
- l. D2285, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
- 2. Insulated Cable Engineers Association (ICEA):
 - a. S-93-639, Shielded Power Cables 5,000V-4,600V.
 - b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
 - c. S-97-682, Utility Shielded Power Cables Rated 5 through 46 kV.
- 3. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
 - b. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators 2.5 kV through 765 kV.
 - c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1): Normal Measurements.
 - d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.
 - e. 386, Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - f. 400, Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.
 - 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. C62.33, Test Specifications for Varistor Surge-Protective Devices.
- 4. National Electrical Testing Association (NETA): Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (ATS).
- 5. 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.
- 6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 70E, Standard for Electrical Safety Requirements for Employee Workplaces.
 - c. 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.

1.4 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. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years testing experience on similar projects.
 - 5. Technicians certified by NICET or NETA.
 - 6. Assistants and apprentices assigned to project at ratio not to exceed two certified to one noncertified assistant or apprentice.
 - 7. Registered Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
 - 8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.
- 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.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. Tests specified in this section shall be performed in accordance with requirements of Division 01, General Requirements.
- 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. Set, test, and calibrate protective relays, circuit breakers, fuses power monitoring meters, and other applicable devices in accordance with values established by the short circuit, coordination and harmonics studies as specified in Section 26 05 70, Electrical Systems Analysis.
- E. Adjust mechanisms and moving parts of equipment for free mechanical movement.
- F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.
- G. Verify nameplate data for conformance to Contract Documents and approved Submittals.
- H. Realign equipment not properly aligned and correct unlevelness.
- I. Properly anchor electrical equipment found to be inadequately anchored.
- J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.
- K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.
- L. Provide proper lubrication of applicable moving parts.
- M. Inform Engineer of working clearances not in accordance with NFPA 70.
- N. 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.
- O. 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.

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

3.2 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 a written certification from a 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 any phase current for any piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.3 SWITCHBOARDS

- 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. 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 or OPEN position.
 - b. Opening attempt of door when device is in ON or CLOSED position.
 - 8. 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.
 - 9. Check nameplates for proper identification of:
 - a. Equipment title and tag number with latest one-line diagram.
 - b. Pushbutton.
 - c. Control switch.

- d. Pilot light.
- e. Control relay.
- f. Circuit breaker.
- g. Indicating meter.
- 10. Verify that fuse and circuit breaker ratings, sizes, and types conform to those specified.
- 11. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench and thermographic survey applied to bolted joints.
 - a. Ohmic value to be zero.
 - b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
 - c. Thermographic survey temperature gradient of 2 degrees C, or less.
- 12. Check operation and sequencing of electrical and mechanical interlock systems by:
 - a. Closure attempt for locked open devices.
 - b. Opening attempt for locked closed devices.
 - c. Key exchange to operate devices in OFF-NORMAL positions.
- 13. Verify performance of each control device and feature.
- 14. 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.
- 15. Exercise active components.
- 16. 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. Control wiring except that connected to solid state components.
 - g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
- 2. Overpotential Tests:
 - a. Applied ac or dc voltage and test procedure in accordance with IEEE C37.20.1 and NEMA PB 2.
 - b. Each phase of each bus section.
 - c. Phase-to-phase and phase-to-ground for 1 minute.
 - d. Test results evaluated on a pass/fail basis.
- 3. 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.
- 4. 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.
- 5. Operational Test:
 - a. Initiate control devices.

- b. Check proper operation of control system in each section.

3.4 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
 - h. established by manufacturer.
 - 2. Ground continuity test ground bus to system ground.

3.5 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 that 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. 10-minute test duration 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.
- 2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.6 LOW VOLTAGE CABLES, 600V MAXIMUM

- A. Visual and Mechanical Inspection:
 - 1. Inspect each individual exposed power cable 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 Specifications.
 - e. Proper circuit identification.
 - 2. Mechanical Connections For:
 - a. Proper lug type for conductor material.
 - b. Proper lug installation.
 - c. Bolt torque level in accordance with NETA ATS, Table 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. 6 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.

3.7 SAFETY SWITCHES, 600 VOLTS MAXIMUM

- A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Proper phase barrier material and installation.
7. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
 - c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
 - a. Contact resistance in microhms across each switch blade and fuse holder.
 - b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.8 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 50 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.

3.9 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

- 1. Visually check each relay for:
 - a. Tight cover gasket and proper seal.
 - b. Unbroken cover glass.
 - c. Condition of spiral spring and contacts.
 - d. Disc clearance.
 - e. Condition of case shorting contacts if present.
- 2. Mechanically check each relay for:
 - a. Freedom of movement.
 - b. Proper travel and alignment.
- 3. Verify each relay:
 - a. Complies with Contract Documents, approved Submittal, and application.
 - b. Is set in accordance with recommended settings from Coordination Study.
- 4. Any changes required to relay programming shall be furnished by the equipment manufacturer. For the adjustable frequency drive, the drive manufacturer shall provide new settings as required.

B. Electrical Tests:

- 1. Insulation resistance test on each circuit to frame, except for solid state devices.
- 2. Test on nominal recommended setting for:
 - a. Pickup parameters on each operating element.
 - b. Timing at three points on time-current curve.
 - c. Pickup target and seal-in units.
 - d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.
- 3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
- 4. 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.

3.10 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

- 1. Visually check current, potential, and control transformers for:
 - a. Cracked insulation.
 - b. Broken leads or defective wiring.
 - c. Proper connections.

- d. Adequate clearances between primary and secondary circuit wiring.
 - 2. Verify mechanically:
 - a. Grounding and shorting connections have good contact.
 - b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
 - 3. Verify proper primary and secondary fuse sizes for potential transformers.
- B. Electrical Tests:
- 1. Current Transformer Tests:
 - a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
 - b. Polarity test.
 - 2. Potential Transformer Tests:
 - a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9 for 1 minute on:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
 - 3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.11 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.

3.12 GROUNDING SYSTEMS

- A. Visual and Mechanical Inspection:
- 1. Equipment and circuit grounds in motor control center, panelboard, switchboard, and switchgear assemblies for proper connection and tightness.
 - 2. Ground bus connections in motor control center, panelboard, switchboard, and switchgear 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).
 - 2. Two-Point Direct Method Test:

- a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
- b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.13 GROUND FAULT SYSTEM

- A. Inspection and testing limited to:
 - 1. Zero sequence grounding systems.
 - 2. Residual ground fault systems.
- B. Visual and Manual Inspection:
 - 1. Neutral main bonding connection to assure:
 - a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
 - b. Ground strap sensing system is grounded through sensing device.
 - c. Neutral ground conductor is solidly grounded.
 - 2. Verify control power has adequate capacity for system.
 - 3. Manually operate monitor panels for:
 - a. Trip test.
 - b. No trip test.
 - c. Nonautomatic rest.
 - 4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
 - 5. Relay check for pickup and time under simulated ground fault conditions.
 - 6. Verify nameplate identification by device operation.
- C. Electrical Tests:
 - 1. Test system neutral insulation resistance with neutral ground link removed. System neutral insulation resistance minimum 1 megohm.
 - 2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
 - 3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.
 - 4. Test system operation at 55 percent rated control voltage, if applicable.
 - 5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.14 AC INDUCTION MOTORS

- A. General: Inspection and testing limited for existing raw water pump motors and new raw water pump No. 5 motor.
- 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.
- 6. Check Ohmic value of RTDs.

C. Electrical Tests:

- 1. Insulation Resistance Tests:
 - a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
 - 1) Motors above 200 hp for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - 2) Motors 200 hp and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.
 - b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
- 2. Calculate polarization index ratios for motors above 200 hp. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
- 3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
- 4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes. Measure and record RTD temperature using MPR display during running.
- 5. Overpotential Tests:
 - a. Applied dc voltage in accordance with IEEE 95.
 - b. Limited to 4,000-volt motors rated 1,000 hp and greater.
 - c. Test results evaluated on pass/fail basis.

3.15 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 or OPEN position.
 - b. Opening attempt of door when device is in ON or CLOSED position.
- 8. Check key interlocking systems for:
 - a. Key captivity when device is in ON or CLOSED position.
 - b. Key removal when device is in OFF or OPEN 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. Pushbuttons.
 - c. Control switches.
 - d. Pilot lights.
 - e. Control relays.
 - f. Circuit breakers.
 - g. Indicating meters.
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 and calibrated torque wrench applied to bolted joints:
 - a. Ohmic value to be zero.
 - b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
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 all connections.
18. Compare overload heater rating with full-load current for proper size.
19. Compare motor protector and circuit breaker 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 boards and each device terminal.
 - c. Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid state components: Insulation resistance to be 1 megohm minimum.
- 4. Operational test by initiating control devices to affect proper operation.

3.16 LOW VOLTAGE SURGE ARRESTORS

- A. Visual and Mechanical Inspection:
 - 1. Adequate clearances between arrestors and enclosures.
 - 2. Ground connections to ground bus or electrode.
- B. Electrical Tests:
 - 1. Varistor Type Arrestors:
 - a. Clamping voltage test.
 - b. Rated RMS voltage test.
 - c. Rated dc voltage test.
 - d. Varistor arrestor test values in accordance with IEEE C62.33, Sections 4.4 and 4.9.

3.17 STANDBY AND EMERGENCY GENERATOR SYSTEMS

- A. Visual and Mechanical Inspection:
 - 1. Proper grounding.
 - 2. Blockage of ventilating passageways.
 - 3. Proper operation of jack water heaters.
 - 4. Integrity of engine cooling and fuel supply systems.
 - 5. Excessive mechanical and electrical noise.
 - 6. Overheating of engine or generator.
 - 7. Proper installation of vibration isolators.
 - 8. Proper cooling liquid type and level.
 - 9. Operate engine-generator and check for:
 - a. Excessive mechanical and electrical noise.
 - b. Overheating.
 - c. Correct rotation.
 - d. Check resistance temperature detectors or generator inherent thermal protectors for functionality and proper operation.
 - e. Excessive vibration.
 - 10. Verify voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.
 - 11. Proper operation of meters and instruments.
 - 12. Compare generator nameplate rating and connection with one-line diagram or approved Submittal.
 - 13. Verify engine-generator operation with adjustable frequency drives energized and operating under normal load conditions.
- B. Electrical and Mechanical Tests:
 - 1. Cold start test by interrupting normal power source with test load consisting of connected building load to verify:
 - a. Transfer switch operation.
 - b. Automatic starting operation.

- c. Operating ability of engine-generator.
 - d. Overcurrent devices capability to withstand inrush currents.
- 2. Phase rotation tests.
- 3. Test engine protective shutdown features for:
 - a. Low oil pressure.
 - b. Overtemperature.
 - c. Overspeed.
- 4. Vibration base-line test on generator sets; levels in accordance with manufacturer's recommendations.
- 5. Load bank test with reactors and resistors adjusted to 80 percent power factor for each load step. Record voltage, frequency, load current, oil pressure, and engine coolant temperature at 15-minute intervals:
 - a. 25 percent applied load for 30 minutes.
 - b. 50 percent applied load for 30 minutes.
 - c. 75 percent applied load for 30 minutes.
 - d. 100 percent applied load for 3 hours.
 - e. Load test results to demonstrate ability of unit to deliver rated load for test period.
- 6. One-Step Rated kW Load Pickup Test:
 - a. Perform test immediately after performing load bank test.
 - b. Apply rated load, minus largest rated hp motor, to generator.
 - c. Start largest rated hp motor and record voltage drop for 20 cycles minimum with high-speed chart recorder or digital storage oscilloscope.
 - d. Compare voltage drop with maximum allowable voltage dip for specified starting situation.

3.18 THERMOGRAPHIC SURVEY

- A. Provide a thermographic survey per NETA ATS Table 100.18 of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 2 and larger at each:
 - 1. Switchboard.
 - 2. Low voltage motor control center.
 - 3. Panelboard.
- B. Provide a thermographic survey of feeder conductors terminating at:
 - 1. Motors rated 600 hp and larger.
 - 2. Engine-generators.
- C. Remove necessary enclosure metal panels and covers prior to performing survey.
- D. Perform with equipment energized during periods of maximum possible loading per NFPA 70B, Section 20.17.
- E. Do not perform survey on equipment operating at less than 20 percent of rated load. If plant load is insufficient, perform test with supplemental load bank producing rated load on item being measured.
- F. Utilize thermographic equipment capable of:
 - 1. Detecting emitted radiation.
 - 2. Converting detected radiation to visual signal.

3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees C.
- G. Temperature Gradients:
1. 3 degrees C to 7 degrees C indicates possible deficiency that warrants investigation.
 2. 7 degrees C to 15 degrees C indicates deficiency that is to be corrected as time permits.
 3. 16 degrees C and above indicates deficiency that is to be corrected immediately.
- H. Provide written report of:
1. Areas surveyed and the resultant temperature gradients.
 2. Locations of areas having temperature gradients of 3 degrees C or greater.
 3. Cause of heat rise and actions taken to correct the cause of heat rise.
 4. Detected phase unbalance.

END OF SECTION

SECTION 26 22 13
LOW VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Eaton
- B. Schneider Electric
- C. ABB
- D. Acme
- E. Engineer's approved equal.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified."

2.3 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Comply with NFPA 70.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- C. Transformers Rated 15 kVA and Larger:
 - 1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
 - 2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.
- D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
- E. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
- F. Coils: Continuous windings except for taps.
 - 1. Coil Material: Aluminum.
 - 2. Internal Coil Connections: Brazed or pressure type.
 - 3. Terminal Connections: Welded.

- G. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.4 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Cores: One leg per phase.
- C. Enclosure: Ventilated.
 - 1. NEMA 250, Type as shown on Electrical Drawings.
 - 2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
 - 3. Wiring Compartment: Sized for conduit entry and wiring installation.
- D. Taps for Transformers 3 kVA and Smaller: None.
- E. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- G. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- H. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.
- I. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.
- J. Wall Brackets: Manufacturer's standard brackets.

2.5 IDENTIFICATION

- A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."
- B. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

3.2 INSTALLATION

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 - 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
- B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.
- C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- D. Secure transformer to concrete base according to manufacturer's written instructions.
- E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:
 - 1. Visual and Mechanical Inspection.
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.
 - 2. Electrical Tests:
 - a. Measure resistance at each winding, tap, and bolted connection.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
 - c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
 - d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

- E. Remove and replace units that do not pass tests or inspections and retest as specified above.
- F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

SECTION 26 24 16 PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.2 DEFINITIONS

- A. MCCB:** Molded-case circuit breaker.
- B. SPD:** Surge protective device.

1.3 ACTION SUBMITTALS

- A. Product Data:** For each type of panelboard.
- B. Shop Drawings:** For each panelboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details.
 2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 3. Detail bus configuration, current, and voltage ratings.
 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 5. Include evidence of NRTL listing for series rating of installed devices.
 6. Include evidence of NRTL listing for SPD as installed in panelboard.
 7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 8. Include wiring diagrams for power, signal, and control wiring.
 9. Key interlock scheme drawing and sequence of operations.
 10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.4 INFORMATIONAL SUBMITTALS

- A. Panelboard schedules** for installation in panelboards.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.**

1.6 FIELD CONDITIONS

A. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

- A. Fabricate and test panelboards according to IEEE 344 to withstand local seismic conditions.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA PB 1.
- D. Comply with NFPA 70.
- E. Enclosures: Surface-mounted, dead-front cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Wet and Corrosive Areas: NEMA 250, Type 4X Stainless Steel.
 - 2. Height: 84 inches maximum.
 - 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
 - 4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
- F. Incoming Mains Location: Bottom.
- G. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity.
- H. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.

3. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- I. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.
 - J. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
 - K. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
 - L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
- B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.3 POWER PANELBOARDS

- A. Manufacturers:
 - Square D/Schneider Electric
 - Eaton
 - ABB/ General Electric
 - Engineer's Approved Equal.
- B. Panelboards: NEMA PB 1, distribution type.

- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit.
- G. Branch Overcurrent Protective Devices: Fused switches.
- H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 - 1. External Control-Power Source: 120-V branch circuit.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers:
 - Square D/Schneider Electric
 - Eaton
 - ABB/ General Electric
 - Engineer's Approved Equal.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker.
- D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- F. Column-Type Panelboards: Single row of overcurrent devices with narrow gutter extension and overhead junction box equipped with ground and neutral terminal buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers:
 - Square D/Schneider Electric
 - Eaton

- ABB/ General Electric
- Engineer's Approved Equal.

B. MCCB: Comply with UL 489, with series-connected rating to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.
 - c. Digital display of settings, trip targets, and indicated metering displays.
 - d. Multi-button keypad to access programmable functions and monitored data.
 - e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
 - f. Integral test jack for connection to portable test set or laptop computer.
 - g. Field-Adjustable Settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long and short time adjustments.
 - 4) Ground-fault pickup level, time delay, and I squared T response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
 - f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

- g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 - h. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
 - i. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

2.6 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in transparent card holder.

2.7 ACCESSORY COMPONENTS AND FEATURES

- A. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install panelboards and accessories according to NEMA PB 1.1.
- C. Comply with mounting and anchoring requirements as required to accommodate local seismic conditions.
- D. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- E. Mount panelboard cabinet plumb and rigid without distortion of box.
- F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.

- H. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- I. Install filler plates in unused spaces.
- J. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- K. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Panelboards will be considered defective if they do not pass tests and inspections.

- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION

SECTION 26 27 26 WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Straight-blade convenience receptacles.
2. USB charger devices.
3. GFCI receptacles.
4. SPD receptacles.
5. Toggle switches.
6. Decorator-style convenience.
7. Wall switch sensor light switches with dual technology sensors.
8. Wall switch sensor light switches with passive infrared sensors.
9. Wall switch sensor light switches with ultrasonic sensors.
10. Digital timer light switches.
11. Residential devices.
12. Wall-box dimmers.
13. Wall plates.

1.2 DEFINITIONS

A. Abbreviations of Manufacturers' Names:

1. Cooper: Copper Wiring Devices; Division of Cooper Industries, Inc.
2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
3. Leviton: Leviton Mfg. Company, Inc.
4. Pass & Seymour: Pass& Seymour/Legrand.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
 - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
 - 2. Devices shall comply with the requirements in this Section.
- D. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
- E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STRAIGHT-BLADE RECEPTACLES

- A. Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

2.3 GFCI RECEPTACLES

- A. General Description:
 - 1. 125 V, 20 A, straight blade, feed-through type.
 - 2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
 - 3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

2.4 TOGGLE SWITCHES

- A. Comply with NEMA WD 1, UL 20, and FS W-S-896.
- B. Switches, 120/277 V, 20 A rated.

2.5 WALL PLATES

- A. Single and combination types shall match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: 0.05-inch-thick, anodized aluminum.
 - 3. Material for Unfinished Spaces: Anodized aluminum.
 - 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.6 FINISHES

- A. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Emergency Power System: Red.
 - 3. SPD Devices: Blue.
 - 4. Isolated-Ground Receptacles: Orange.
- B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailling existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that 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 the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. GFCI Receptacles: Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.2 FIELD QUALITY CONTROL

- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

- C. Perform the following tests and inspections as required.
1. Tests for Convenience Receptacles:
- a. Line Voltage: Acceptable range is 105 to 132 V.
 - b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 - c. Ground Impedance: Values of up to 2 ohms are acceptable.
 - d. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - e. Using the test plug, verify that the device and its outlet box are securely mounted.
 - f. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- D. Wiring device will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION

SECTION 26 29 23

VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 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.

1.2 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 transistor logic.

1.3 AFD MANUFACTURER REQUIREMENTS

- A. All adjustable frequency drives shall be of the same manufacturer selected as listed under acceptable manufacturers. The Contractor shall also be responsible for coordinating with his various subcontractors to ensure that the same AFD manufacturer is provided in all vendor control panels that are provided as part of this project. AFDs from alternate manufacturers will not be considered.

1.4 SPECIAL PROJECT REQUIREMENTS

- A. The Contractor shall be responsible for coordinating the drive requirements with the manufacturer of the load which the AFD shall operate in order to ensure that the correct type of drive (i.e. constant torque or variable torque) is provided for each application. In order to ensure that the Contractor has properly coordinated the specific type of drive to be provided for each particular process, the submittals for all adjustable frequency drives shall include a letter from the manufacturer of the specific load that will be energized from the AFD to indicate if the specific application requires a constant torque drive or a variable torque drive.
- B. The Contractor shall be responsible for coordinating with the AFD manufacturer on the actual feeder distances required in order to ensure that the appropriate type of output filters, or dv/dt filters, are provided, where required. In order to ensure that the Contractor has properly coordinated with the AFD manufacturer, all submittals for AFDs shall include a letter from the AFD manufacturer that indicates that they have coordinated with the Contractor on the actual feeder lengths required and that the appropriate type of output filters, or dv/dt filters, are provided as proposed within the submittal.

1.5 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: All adjustable frequency drives provided shall be sized 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. As part of the AFD submittal, the manufacturer shall include the ampacity ratings of the each proposed AFD as well as the motor nameplate FLA for the associated motor.
3. Basis for Harmonic Computations: Using Contract Drawings for current and voltage distortion computations, furnish harmonic filters, line reactors, isolation transformers, or higher pulse converter arrangements required to meet current/voltage distortion limits.
4. Normal and Standby Source Current Harmonic Distortion:
 - a. Compute normal and Standby source individual and total current harmonic distortion at the bus of low voltage switchgear SWBD-IPS-1. The bus of switchboard shall be defined at the point of common coupling (PCC1) in accordance with IEEE 519.
 - b. Individual current harmonic distortion and total demand distortion expressed as percent of maximum demand load current I_L shall not exceed values specified in Table 1 below:

Table 1	
Individual Harmonic Order (Odd Harmonics)	Harmonic Current Distortion Percent of Max. Demand Load Current IL
h <11	4.0
11 h <17	2.0
17 h <23	1.5
23 h <35	0.6
35 h	0.3
Total Demand Distortion (TDD)	5.0

- c. Limits specified in Table 1 above are for drives utilizing 6-pulse rectifiers. Should manufacturer propose higher pulse rectifiers, limits for characteristic harmonics listed in Table 1 can be increased accordingly as indicated in IEEE 519 depending on the pulse drive that is proposed.
 - d. The harmonic analysis for each distribution system shall be performed under each of the possible modes of operation:
 - 1) Normal mode of operation
 - 2) Emergency mode of operation
5. Normal and Standby Source Voltage Harmonic Distortion: Compute normal and standby source voltage harmonic distortion at location identified as PCC1. THD shall not exceed 5 percent, and individual voltage harmonic distortion shall not exceed 3 percent.
 6. Furnish isolating transformers or series reactors, harmonic filters, 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. The final number and ratings of the harmonic filters required shall be determined by the manufacturer based on the results of the harmonics study specified herein.
 7. 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: All 6-pulse AFDs shall include a 5 percent input line reactor. Design to minimize harmonic distortion on incoming power feeder.

C. Specific AFD Requirements:

- a. 6-pulse AFD with 5 percent input line reactor. AFD shall be located within the MCC.
- b. Output dV/dt filters.
- c. Ethernet communication with MCC Ethernet switch via EtherNet/IP protocol.
- d. See Control Diagrams for additional requirements.
- e. AFD shall be sized a minimum of 1.15 x the motor nameplate FLA.

1.6 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. Individual and total harmonic content (voltage and current) reflected in system normal source supply at driven equipment actual load at 70 percent and 100 percent of rated speed at locations specified in Simplified Plant One-Line Diagram and load conditions specified. Use TDD and THD factors as defined in IEEE 519 to designate total harmonic content.
3. Individual and total current and voltage harmonic content reflected in

standby power source, at locations specified in this section, at driven equipment actual load at 70 percent and 100 percent of rated speed determined by using actual size and subtransient reactance of standby system obtained from standby source manufacturer. Use TDD and THD factors as defined in IEEE 519 to designate total harmonic content.

4. 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.
5. Data on shelf life of "dc link" capacitor.
6. Complete system rating, including nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.
7. Complete adjustable frequency controller rating coordinated with motor full load nameplate current rating; list controller special features being supplied.
8. Controller, reactor, harmonic filter, and isolating transformer (if applicable) dimensional drawings; information on size and location of space for incoming and outgoing conduit.
9. Maximum heat dissipation from enclosure.
10. Should separate enclosures and equipment be necessary for filter 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.
11. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.
12. Complete system operating description.
13. Complete system schematic (elementary) wiring diagrams.
14. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to system, including wire numbers and terminal board point identification.
15. One-line diagram of system, including component ratings.
16. Description of diagnostic features being provided.
17. Descriptive literature for control devices such as relays and timers.
18. Itemized bill-of-materials listing system components.
19. Specific description of provisions, such as filtering and harmonic suppression, being made to ensure proper system operation when system is supplied from either the normal utility source or the standby generation. Additionally, the AFD manufacturer shall coordinate the sizing of the active harmonic filters required to meet the requirements of IEEE 519.

B. Informational Submittals:

1. Statement of Supplier qualifications.

2. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer's printed installation instructions.
5. Factory functional test reports.
6. Certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE 112, Test Method B, showing rated load, rated speed efficiency meeting or exceeding specified values; motors not as specified will be rejected.
7. Field test reports.
8. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
9. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
10. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
11. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
12. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.7 QUALITY ASSURANCE

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

1.8 EXTRA MATERIALS

- A. Furnish for each drive unit:
 1. Complete set of components likely to fail in normal service.
 2. Plug-in subassemblies.
 3. Printed circuit boards.
 4. SCRs.
 5. Potentiometers.
 6. Integrated circuits.
 7. One complete power bridge and one spare printed circuit card for each modular, plug-in type card in controller.
 8. One spare fan for each type AFD package.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Square D
- B. Eaton
- C. Allen-Bradley
- D. ABB
- E. Or approved equal.

2.2 SYSTEM DESCRIPTION

- A. General Requirements for VFDs:
 - 1. VFDs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.
- B. Application: As shown on the Drawings.
- C. VFD Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
 - 1. Units suitable for operation of NEMA MG 1 motors.
 - 2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- F. Unit Operating Requirements:
 - 1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
 - 2. Input AC Voltage Unbalance: Not exceeding 5 percent.

3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
 4. Minimum Efficiency: 96 percent at 60 Hz, full load.
 5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
 6. Minimum Short-Circuit Current (Withstand) Rating: 42 kA.
 7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
 8. Humidity Rating: Less than 95 percent (noncondensing).
 9. Altitude Rating: Not exceeding 3300 feet.
 10. Vibration Withstand: Comply with NEMA ICS 61800-2.
 11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 13. Speed Regulation: Plus or minus 5 percent.
 14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
 15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.
- H. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical.
- I. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 0.1 to 10 seconds.
 4. Deceleration: 0.1 to 10 seconds.
 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- J. Self-Protection and Reliability Features:
1. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2.
 2. Surge Suppression: Field-mounted surge suppressors complying with UL 1449 SPD, Type 2.
 3. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 4. Under- and overvoltage trips.
 5. Inverter overcurrent trips.
 6. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 7. Critical frequency rejection, with three selectable, adjustable deadbands.

8. Instantaneous line-to-line and line-to-ground overcurrent trips.
 9. Loss-of-phase protection.
 10. Reverse-phase protection.
 11. Short-circuit protection.
 12. Motor-temperature fault.
- K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- M. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- P. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of VFD input current rating.
 2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.
 3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
 4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
 5. NC/NO alarm contact that operates only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFDs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.
1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified".
- B. Provide 3% load reactors when the distance between the VFD and the motor exceeds 50 feet, 5% load reactors when it exceeds 150 feet, and dV/dT filters when it exceeds 250 feet.

2.4 CONTROLS AND INDICATION

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:
1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Overcurrent.
 6. External fault.
- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 2. Security Access: Provide electronic security access to controls through identification and password with at least one level of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
 2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last four faults with time and date stamp for each.
- D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFD door and connected to display VFD parameters including, but not limited to:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (V dc).
 9. Set point frequency (Hz).
 10. Motor output voltage (V ac).
- E. Control Signal Interfaces:

1. Electric Input Signal Interface:
 - a. A minimum of two programmable analog inputs: 4- to 20-mA dc.
 - b. A minimum of six multifunction programmable digital inputs.
 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
 - a. 0- to 10-V dc.
 - b. 4- to 20-mA dc.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 3. Output Signal Interface: A minimum of one programmable analog output signal (4- to 20-mA dc), which can be configured for any of the following:
 - a. Output frequency (Hz).
 - b. Output current (load).
 - c. DC-link voltage (V dc).
 - d. Motor torque (percent).
 - e. Motor speed (rpm).
 - f. Set point frequency (Hz).
- F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
1. Number of Loops: One.
- G. Each VFD shall be equipped with EtherNet communication port for interface with the plant SCADA system or with MCC EtherNet switch. The protocol shall be TCP/IP and shall be coordinated with the plant system integrator.

2.5 ENCLOSURES

- A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 1. Wet and Corrosive Locations: Type 4X Stainless Steel.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.6 ACCESSORIES

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFD enclosure cover unless otherwise indicated.

1. Push Buttons: Unguarded.
 2. Pilot Lights: Push to test.
 3. Selector Switches: Rotary type.
- B. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
- C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.
- D. Supplemental Digital Meters:
1. Elapsed-time meter.
 2. Kilowatt meter.
 3. Kilowatt-hour meter.
- E. Air Conditioner: For NEMA 250, Type 4X; UL 508 component; 120V ac obtained from integral CPT.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall.
- B. Seismic Bracing: Comply with requirements as required for local seismic conditions.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in each fusible-switch VFD.
- E. Install fuses in control circuits if not factory installed.
- F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.
- G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

- H. Comply with NECA 1.

3.2 CONTROL WIRING INSTALLATION

- A. Install wiring between VFDs and remote devices.
- B. Bundle, train, and support wiring in enclosures.

3.3 IDENTIFICATION

- A. Identify VFDs, components, and control wiring.
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFD with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections as required.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
 - 3. Test continuity of each circuit.
 - 4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
 - 5. Test each motor for proper phase rotation.
 - 6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

- D. VFDs will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.
- D. Set field-adjustable circuit-breaker trip ranges as required.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION

SECTION 26 32 13

ENGINE DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 REFERENCES

The equipment covered by these specifications shall be designed, tested, rated, assembled and installed in strict accordance with all applicable standards of ANSI, NEC, ISO, U.L., IEEE and NEMA.

1.2 WORK INCLUDED

- A. The work includes supplying a complete integrated emergency generator system. The system consists of a diesel generator set with related component accessories as specified herein.
- B. The Contractor shall provide a full tank of diesel fuel for the completion of all testing.
- C. A complete system load test shall be performed after all equipment is installed.
- D. The equipment supplied and installed shall meet the requirements of the NEC and all applicable local codes and regulations. All equipment shall be of new and current production by a Manufacturer who has 25 years of experience building this type of equipment. Manufacturer shall be ISO9001 certified.

1.3 MANUFACTURERS

- A. There shall be one source responsibility for warranty, parts and service through a local representative with factory trained service personnel.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Generator Set
 - a. Cummins
 - b. Caterpillar
 - c. Kohler
 - d. Generac.
 - 2. Automatic Transfer Switch
 - a. ASCO
 - b. Caterpillar

- c. Cummins
- d. Generac.

1.4 SUBMITTALS

A. Engine-generator submittals shall include the following information

1. Factory published specification sheet indicating standard and optional accessories, ratings, etc.
2. Manufacturer's catalog cut sheets of all auxiliary components such as Automatic Transfer Switches, battery charger, control panel, enclosure, main circuit breaker, etc.
3. Dimensional elevation and layout drawings of the generator set, enclosure and transfer switchgear and related accessories.
4. Weights of all equipment.
5. Concrete pad recommendation, layout and stub-up locations of electrical and fuel systems.
6. Interconnect wiring diagram of complete emergency system, including generator, switchgear, day tank, remote pumps, battery charger, jacket water heater, remote alarm indications.
7. Engine mechanical data including heat rejection, exhaust gas flows, combustion air and ventilation air flows, noise data, fuel consumption, etc.
8. Generator electrical data including temperature and insulation data, cooling requirements, excitation ratings, voltage regulation, voltage regulator, efficiencies, waveform distortion and telephone influence factor.
9. Generator resistances, reactances, and time constants.
10. Generator motor starting capability.
11. Control panel schematics.
12. Oil sampling analysis, laboratory location, and information.
13. Manufacturer's and dealer's written warranty.
14. Letter of guarantee that the proposed generator will be capable of starting and running the loads specified on the drawings.

1.5 WARRANTY

- A. The manufacturer's standard warranty shall in no event be for a period of less than two (2) years from date of substantial completion and shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Submittals received without written warranties as specified will be rejected in their entirety.

1.6 PARTS AND SERVICE QUALIFICATIONS

- A. The engine-generator supplier shall have service facilities within 75 miles of the project site and maintain 24-hour parts and service capability. The distributor shall stock parts as needed to support the generator set package for this specific project.
- B. The dealer shall maintain qualified, factory trained service personnel that can respond to an emergency call within 4 hours of notification, 24 hours per day.

PART 2 - PRODUCTS

1.1 GENERAL REQUIREMENTS

- A. The generator set shall be Standby and have a kW rating as shown on the one line diagram. The additional ratings shall be 1800 RPM, 0.8 power factor, 480Y/277 VAC, 3 phase, 4 wire, 60 hertz, including radiator fan and all parasitic loads.
- B. All materials and parts comprising the unit shall be new and unused.

1.2 DIESEL ENGINE

- A. The engine shall be water-cooled inline or vee-type, four cycle compression ignition diesel. It shall meet specifications when operating on number 2 domestic burner oil. Two cycle engines will not be considered. The engine shall be equipped with fuel, lube oil, and intake air filters, lube oil cooler, fuel transfer pump, fuel priming pump, service meter, gear-driven water pump.
- B. The complete engine block shall be machined from one casting. Designs incorporating multiple blocks bolted together are not acceptable.
- C. The engine shall utilize a gear-type, positive displacement, full pressure lubricating oil pump and water-cooled lube oil cooler. Pistons shall be spray-cooled. Provide oil filters, oil pressure gauge, dipstick and oil drain.
- D. Fuel filter and serviceable fuel system components shall be located to prevent fuel from spilling onto generator set batteries.
- E. The engine shall be equipped with an isochronous electronic governor to maintain 0% droop from no load to full load and +/- 0.25% steady state frequency variation. The governor shall be equipped with speed adjustment.

1.3 GENERATOR

- A. The synchronous generator shall be a single bearing, self-ventilated, drip-proof design in accordance with NEMA MG 1 and directly connected to the engine flywheel housing with a flex coupling.
- B. The insulation material shall meet NEMA standards for Class H insulation and be vacuum impregnated with epoxy varnish to be fungus resistant. Temperature

rise of the rotor and stator shall not exceed NEMA class F (130° C rise by resistance over 40° C ambient). The excitation system shall be of brushless construction.

- C. The brushless exciter shall be independent of main stator windings (either permanent magnet or auxiliary windings) and shall consist of a three-phase armature and a three-phase full wave bridge rectifier mounted on the rotor shaft. Surge suppressors shall be included to protect the diodes from voltage spikes. Generator shall have the ability to sustain short circuit current of 300% of rated current to allow protective devices to operate.
- D. The automatic voltage regulator (AVR) shall maintain generator output voltage within +/- 0.5% for any constant load between no load and full load. The regulator shall be a totally solid state design which includes electronic voltage buildup, volts per Hertz regulation, three phase sensing, over-excitation protection, loss of sensing protection, temperature compensation, shall limit voltage overshoot on startup, and shall be environmentally sealed.

1.4 CIRCUIT BREAKER

- A. Provide a generator mounted circuit breaker, molded case or insulated case construction. Breaker shall be sized as shown on the drawings. Breaker shall be Merlin Gerin or equal and utilize a thermal magnetic trip unit and 24 VDC shunt trip. The breaker shall be UL listed with shunt trip device connected to engine/generator safety shutdowns. Breaker shall be housed in an extension terminal box mounted on the side of the generator. Mechanical type lugs, sized for the circuit breaker feeders shown on drawing, shall be supplied on the load side of breaker. Breaker shall include long term, short term instantaneous, and ground fault protection.

1.5 CONTROLS

A. Generator Mounted Control Panel:

- 1. Provide a generator mounted control panel for complete control and monitoring of the engine and generator set functions. Panel shall include automatic start/stop operation, adjustable cycle cranking, digital LCD AC metering (0.5% true rms accuracy) with phase selector switch, digital engine monitoring, shutdown sensors and alarms with horn and reset, adjustable cooldown timer and emergency stop push-button. Panel shall incorporate self-diagnostics capabilities and fault logging. Critical components shall be environmentally sealed to protect against failure from moisture and dirt. Components shall be housed in a NEMA 1/IP22 enclosure with hinged lid.
- 2. Provide the following digital readouts on the Generator Mounted Control Panel:
 - a. Engine oil pressure

- b. Coolant temperature
 - c. Engine RPM
 - d. System DC Volts
 - e. Engine running hours
 - f. Generator AC volts
 - g. Generator AC amps
 - h. Generator frequency
3. Control Panel Annunciation - Provide the following indications for protection and diagnostics according to NFPA 110 level 1:
- a. Low oil pressure
 - b. High water temperature
 - c. Low coolant level
 - d. Overspeed
 - e. Overcrank
 - f. Emergency stop depressed
 - g. Approaching high coolant temperature
 - h. Approaching low oil pressure
 - i. Low coolant temperature
 - j. Low voltage in battery
 - k. Control switch not in auto. position
 - l. Low fuel main tank
 - m. Battery charger ac failure
 - n. High battery voltage
 - o. Generator supplying load
 - p. Spare.
4. Generator "Running", "Common Fault" and "Low Fuel Level" relays with dry, 120VAC, 5 Amp rated contacts.

B. COOLING SYSTEM

1. The generator set shall be equipped with a rail-mounted, engine-driven radiator with blower fan and all accessories. The cooling system shall be sized to operate at full load conditions and 110° F ambient air entering the room or enclosure (If an enclosure is specified) without derating the unit and 50/50 anti-freeze mixture. The generator set supplier is responsible for providing a properly sized cooling system based on the enclosure static pressure restriction.

C. FUEL SYSTEM

1. Filter/Separator - In addition to the standard fuel filters provided by the engine manufacturer, there shall also be installed a primary fuel filter/water separator in the fuel inlet line to the engine.
2. All fuel piping shall be black iron or flexible fuel hose rated for this service. No galvanized piping will be permitted.
3. Flexible fuel lines shall be rated for 300 degrees F and 100 PSI.
4. Fuel Tank shall be double wall with Leak Detection.

D. EXHAUST SYSTEM

1. A critical type silencer, companion flanges, and flexible stainless steel exhaust fitting properly sized shall be furnished and installed according to the manufacturer's recommendation.
2. Mounting shall be provided by the contractor as shown on the drawings. The silencer shall be mounted so that its weight is not supported by the engine.
3. Exhaust pipe size shall be sufficient to ensure that exhaust back pressure does not exceed the maximum limitations specified by the engine manufacturer.

E. STARTING SYSTEM

1. A DC electric starting system with positive engagement shall be furnished. The motor voltage shall be as recommended by the engine manufacturer.
2. Jacket Water Heater: A unit mounted thermal circulation type water heater. The heater watt rating shall be sized by the manufacturer to maintain jacket water temperature at 90 degrees F, and shall be a 120 volt, single phase, 60 hertz.
3. Batteries: A lead-acid storage battery set of the heavy duty diesel starting type shall be provided. Battery voltage shall be compatible with the starting

system. The battery set shall be rated no less than 140 ampere hours and 1000 CCA. Necessary cables and clamps shall be provided.

4. A battery tray shall be provided for the batteries and shall conform to NEC 480-7(b). It shall be treated to be resistant to deterioration by battery electrolyte. Further, construction shall be such that any spillage or boil-over battery electrolyte shall be contained within the tray to prevent a direct path to ground.
5. Battery Charger: A current limiting battery charger shall be furnished to automatically recharge batteries. Charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressor, DC ammeter, DC voltmeter, and fused AC input. AC input voltage shall be 120 volts, single phase. Charger shall have LED annunciation for low DC volts, rectifier failure, loss of AC power, high DC volts. Amperage output shall be as required. Charger shall be wall mounting type in NEMA 1 enclosure, installed in the generator set enclosure.

F. GENERATOR SET ENCLOSURE – SOUND ATTENUATED AND WEATHER PROTECTIVE

1. The complete diesel engine generator set, including generator control panel, engine starting batteries and fuel oil tank, shall be enclosed in a factory assembled, weather protective enclosure mounted on the fuel tank base.
2. The enclosure shall be constructed of corrosion resistant steel with electrostatically applied powder coated baked polyester paint. It shall consist of a roof, side walls, and end walls. Fasteners shall be either zinc plated or stainless steel.
3. A dual wall fuel tank base of 24 hour capacity at 100% load shall be provided as an integral part of the enclosure. It shall be contained in a rupture basin with 110% capacity. The tank shall be pressure tested for leaks prior to shipment and have all necessary venting per UL142 standards. A locking fill cap, a mechanical reading fuel level gauge, low fuel level alarm contact, and fuel tank rupture alarm contact shall be provided.
4. The enclosure shall reduce the ambient noise level at full load to a maximum of 75 dB at 23 feet.
5. Number of doors on enclosure shall be as required so that all normal maintenance operations, such as lube oil change, filter change, belt adjustment and replacements, hose replacements, access to the control panels, etc., may be accomplished without disassembly of any enclosure components. Access doors shall be fabricated of the same material as the enclosure walls and shall be reinforced for rigidity.

6. Handles shall be key lockable, all doors keyed alike, and hinges shall be zinc die cast or stainless steel. Fasteners shall be zinc plated or stainless steel. Doors shall be of a lift off design allowing one person to remove door if necessary.
7. Air handling will be sized and designed by the manufacturer for 0.5" static pressure drop through enclosure. Intake openings shall be screened to prevent the entrance of rodents.
8. Lube oil and coolant drains shall be extended to the exterior of the enclosure and terminated with drain valves. Radiator access shall be through a hinged, lockable cover on enclosure. Cooling fan and charging alternator shall be fully guarded to prevent injury.
9. Lifting points shall be provided on base frame suitable for lifting combined weight of base tank, generator set and enclosure.

G. AUTOMATIC TRANSFER SWITCH

1. General

- a. The generator vendor shall include Automatic transfer switch with Open Transition, Service Entrance rated Contactor Type.
- b. Transfer switch shall have an enclosure type, number of poles, voltage and ampacity rating as shown on the Drawings and shall have 600-volt insulation on all parts in accordance with NEMA standards.
- c. The current rating shall be a continuous rating when the switch is installed in an unventilated enclosure and shall conform to NEMA temperature rise standards. Designs which require cabinet ventilation are unacceptable and do not meet this specification.
- d. The unit shall be rated based on all classes of loads, i.e., resistive, tungsten, ballast and inductive loads. Switches rated 400 amperes or less shall be UL listed for 100% tungsten lamp load.
- e. As a precondition for approval, all transfer switches complete with accessories shall be listed by Underwriters Laboratories, under Standard UL 1008 (automatic transfer switches) and approved for use on emergency systems.
- f. The withstand current capacity of the main contacts shall not be less than 20 times the continuous duty rating when coordinated with any molded case circuit breaker established by certified test data.
- g. Temperature rise tests in accordance with UL 1008 shall have been conducted after the overload and endurance tests to confirm the ability of the units to carry their rated currents within the allowable temperature limits.
- h. Transfer switches shall comply with the applicable standards of UL, CSA, ANSI, NFPA, IEEE, NEMA and IEC.
- i. The transfer switches shall be supplied with a solid-state control panel as detailed further in these specifications.

2. Sequence of Operation

- a. The ATS shall incorporate adjustable three phase under-voltage sensing of the normal source.
- b. When the voltage of any phase of the normal source is reduced to 80% of nominal voltage, for a period of 0-10 seconds (programmable) a pilot contact shall close to initiate starting of the engine generator.
- c. The ATS shall incorporate adjustable single-phase under-voltage sensing of the emergency source.
- d. When the emergency source has reached a voltage value within 10% of nominal voltage and achieved frequency within 5% of the rated value, the load shall be transferred to the emergency source after a programmable time delay.
- e. When the normal source has been restored to not less than 90% of rated voltage on all phases, the load shall be re-transferred to the normal source after a time delay of 0 to 30 minutes (programmable). The generator shall run unloaded for 5 minutes (programmable) and then automatically shut down. The generator shall be ready for automatic operation upon the next failure of the normal source.
- f. If the engine generator should fail while carrying the load, retransfer to the normal source shall be made instantaneously upon restoration of proper voltage (90%) on the normal source.
- g. The transfer switch shall be equipped with a solid-state control panel. The control panel shall perform the operational and display functions of the transfer switch. The display functions of the control panel shall include ATS position and source availability.
- h. The control panel shall include indicators for timing functions, and ATS test switch.
- i. The transfer switch shall include 120VAC, 2 Amp rated dry contact for connection to SCADA system:
 - 1) Transfer Switch Emergency Position
 - 2) Transfer Switch Normal Position
- j. The control panel shall be provided with calibrated pots (accessible only by first opening the lockable cabinet door) to set time delays, voltage and frequency sensors. The ATS shall be capable of being adjusted while the controls are energized and the unit in automatic mode. Designs which force a "programming mode" or require the controls be de-energized during adjustment are unacceptable.
- k. The control panel shall be opto-isolated from its inputs to reduce susceptibility to electrical noise and provided with the following inherent control functions and capabilities:
 - 1) An LED display for continuous monitoring of the ATS functions.
 - 2) Test switch to simulate a normal source failure.
 - 3) Time delay to override momentary normal source failure prior to engine start. Field programmable 0-10 seconds (continuously adjustable via a calibrated potentiometer factory set at 3 seconds.

- 4) Time delay on retransfer to normal source, continuously adjustable 0-30 minutes, factory set at 30 minutes. If the emergency source fails during the retransfer time delay, the transfer switch controls shall automatically bypass the time delay and immediately retransfer to the normal position.
- 5) Time delay on transfer to emergency, continuously adjustable 0-15 seconds, factory set at 1 second.
- 6) An in-phase monitor or time delayed neutral shall be provided to prevent excessive transient currents from switching motor loads.
- 7) An interval-type automatic clock exerciser with load/no load select ability shall be incorporated in the ATS.

3. Construction and Performance

- a. The automatic transfer switch shall be of double throw construction operated by a reliable electrical mechanism momentarily energized. There shall be a direct mechanical coupling to facilitate transfer in 6 cycles or less.
- b. The normal and emergency contacts shall be mechanically interlocked such that failure of any coil or disarrangement of any part shall not permit a neutral position.
- c. For switches installed in systems having ground fault protective devices, and/or wired to be designated a separately derived system by the NEC, a 4th pole shall be provided. This additional pole shall isolate the normal and emergency neutrals. The neutral pole shall have the same withstand and operational ratings as the other poles and shall be arranged to break last and make first to minimize neutral switching transients. Add-on or accessory poles that are not of identical construction and withstand capability are not acceptable.
- d. The contact structure shall consist of a main current carrying contact, which is a silver alloy with a minimum of 50% silver content. The current carrying contacts shall be protected by silver tungsten arcing contacts on all sizes above 400 Amps.
- e. The transfer switch manufacturer shall submit test data for each size switch required for this project, showing that it can withstand fault currents of the magnitude and the duration necessary to maintain the system integrity. Minimum UL listed withstand and close into fault ratings shall be as follows:

- 1) Any Molded Case Breaker*:

Size (Amps)	(RMS Symmetrical)
Up to 200	10,000
201 - 260	35,000
261 - 400	35,000
401 - 1200	50,000
1201 - 4000	100,000

- 2) Specific Coordinated Breaker*:

Size (Amps)	(RMS Symmetrical)
Up to 150	30,000
151 - 260	42,000
261 – 400	50,000
401 - 800	65,000
801 - 1200	85,000
1201 - 4000	100,000

3) Current Limiting Fuse*:

Size (Amps)	(RMS Symmetrical)
Up to 4000	200,000

* All values 480 volt, RMS symmetrical, less than 20% power factor.

Note: Actual necessary current withstand ratings for this project may be higher than the minimums listed above. Refer to electrical plans for exact requirements.

- f. The automatic transfer switch manufacturer shall certify sufficient arc interrupting capabilities for 50 cycles of operation between a normal and emergency source that are 120 degrees out of phase at 480 volts, 600% of rated current at .50 power factor. This certification is to ensure that there will be no current flow between the two isolated sources during switching.
- g. All relays shall be continuous duty industrial type with wiping contacts. Customer interface contacts shall be rated 10 amperes minimum. Coils, relays, timers and accessories shall be readily front accessible. The control panel and power section shall be interconnected with a harness and keyed disconnect plugs for maintenance.
- h. Main and arcing contacts shall be visible without major disassembly to facilitate inspection and maintenance.
- i. A manual handle shall be provided for maintenance purposes with the switch de-energized. An operator disconnect switch shall be provided to defeat automatic operation during maintenance, inspection or manual operation.
- j. The switch shall be mounted in a NEMA 1 enclosure as indicated on the plans.
- k. Switches composed of molded case breakers, contactors or components thereof not specifically designed as an automatic transfer switch will not be acceptable.
- l. To afford the advantage of a sole source of supply to the owner, the automatic transfer switch shall be supplied by the manufacturer of the engine generator set and covered under the same warranty program.

PART 3 - EXECUTION

1.1 INSTALLATION

- A. Install equipment in accordance with manufacturer's recommendations, the project drawings and specifications, and all applicable codes. Installation of the system includes but is not limited to pouring a concrete pad for the generator set and automatic transfer switch, receiving and offloading the equipment, providing all labor, permits and material to install the total system.
- B. Start-Up and Testing
 - 1. Coordinate all start-up and testing activities with the Engineer and Owner.
 - 2. After installation is complete and normal power is available, the manufacturer's local dealer shall perform the following:
 - 3. Verify that the equipment is installed properly.
 - 4. Check all auxiliary devices for proper operation, including battery charger, jacket water heater(s), generator space heater, remote annunciator, etc.
 - 5. Test all alarms and safety shutdown devices for proper operation and annunciation.
 - 6. Check all fluid levels.
 - 7. Start engine and check for exhaust, oil, fuel leaks, vibrations, etc.
 - 8. Verify proper voltage and phase rotation at the transfer switch before connecting to the load.
 - 9. Connect the generator to building load and verify that the generator will start and run all designated loads in the plant.
 - 10. Perform a 4 hour load bank test at full nameplate load using a load bank and cables supplied by the local generator dealer. Observe and record the following data at 15 minute intervals:
 - a. Service meter hours
 - b. Volts AC - All phases
 - c. Amps AC - All phases
 - d. Frequency
 - e. Power factor or Vars
 - f. Jacket water temperature
 - g. Oil Pressure
 - h. Fuel pressure
 - i. Ambient temperature
 - 11. Operation and Maintenance Manuals
 - a. Provide three (3) sets of operation and maintenance manuals covering the generator, switchgear, and auxiliary components. Include parts manuals, final as-built wiring interconnect diagrams and recommended preventative maintenance schedules.

1.2 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 - 2. Review data in maintenance manuals.
 - 3. Schedule training with Owner, with at least seven days' advance notice.
 - 4. Minimum Instruction Period: Four hours.

END OF SECTION

SECTION 31 00 00

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes: Excavation, handling, re-handling, backfilling, compaction, disposal, dewatering of excavated areas, backfilling around structures, backfilling around utilities, preparation of subgrade, surfacing and grading.
- B. Related Sections:
 - 1. Section 03 30 00 - Cast-In-Place Concrete: Concrete materials.
 - 2. Division 40 - Piping
 - 3. Section 32 92 19 - Seeding.
 - 4. Section 32 92 23 - Sodding.
 - 5. Section 31 25 13 – Erosion Controls: Riprap.

1.02 REFERENCES

- A. Georgia Department of Transportation Standard Specification (GDOT Specifications).
- B. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- C. ASTM International:
 - 1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - 2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)).
 - 3. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - 4. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
 - 5. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 6. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

PART 2 PRODUCTS

2.01 TOPSOIL

- A. Topsoil: Natural; friable; graded; free of roots, rocks larger than ½ inch, subsoil, debris, large weeds, and foreign matter. Single screened.

2.02 STRUCTURAL FILL

- A. Structural fill: Select fill, Gravel, sandy gravel, or gravelly sand; free of organic material, loam, wood, trash, snow, ice, frozen soil and other objectionable material and shall be well graded within the following limits:

<u>Sieve Size</u>	<u>Percent Finer by Weight</u>
4-in	100
No. 4	20 to 70
No. 40	5 to 35
No. 200	0 to 7

2.03 BACKFILL

- A. Foundation:
1. Size No. 3 (2" – 1"): ASTM D448, Table 1, standard sizes of processed aggregates.
 2. Size No. 357 (2" – No. 4): ASTM D448, Table 1, standard sizes of processed aggregates.
- B. Granular: 1-1/2 inch graded aggregate base (GAB) which meets the following gradation:

SIZE	% PASSING
2"	100
1-1/2"	97 - 100
3/4"	60 - 90
No. 10	25 - 45
No. 60	5 - 30
No. 200	0 - 15

- C. Select:
1. Cohesionless; classified by Unified Soil Classification System as GW, GP, GM, GC, SW, and SP.
 2. Free of wood, organic material, debris, foreign matter, and rocks larger than 2 inches.
- D. Common:
1. Excavated material: Free of wood, vegetable matter, debris, foreign matter, and rocks larger than 3 inches.
- E. Soil Cement Material (Pug Mix)
1. Soil cement mixture complying with Section 814.2.02 of the GDOT specifications and placed in accordance with the applicable provisions of Section 301 of the GDOT "Standard Specifications Construction of Transportation Systems", latest edition.

- F. Flowable Fill Grout: Flowable fill grout shall be a mixture of sand, fly ash cement and water that will produce a material that can be used in lieu of compacted soil. Air entrainment may be used up to 30% maximum. The finished produce shall have a 28 day compression strength of 100 psi.

2.04 CONCRETE

- A. Class "A" concrete as specified in Section 03 30 00 Cast-in-Place Concrete.

2.05 BEDDING STONE

- A. Size No. 6 (3/4" – 3/8"): ASTM D448, Table 1, standard sizes of processed aggregates.
- B. Size No. 89 (1" – No.4): ASTM D448, Table 1, standard sizes of processed aggregates.

2.06 EMBEDMENT MATERIALS

- A. Defined according to the Unified Soil Classification System (USCS) in ASTM D2487, Standard Method for Classification of Soils for Engineering Purposes and ASTM D2321.
- B. Class I – Angular, ¼ to 1-½ inches (6 to 40 mm) graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed shells, and crushed stone.
- C. Class II – Coarse sands and gravels with maximum particle size of 1-½ in. (40 mm), including variously graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW and SP are included in this class.
- D. Class III – Fine sand and clayey (clay filled) gravels, including fine sands, sand-clay mixtures, and gravel-clay mixtures. Soil Types GM, GC, SM, and SC are included in this class.
- E. Class IV – Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types MH, ML, CH and CL are included in this class.
- F. Class V – This class includes the organic soils OL, OH, and PT as well as soils containing frozen earth, debris, rocks larger than 1-½ in. (40 mm) in diameter, and other foreign materials. These materials are not recommended for bedding, haunching, or initial backfill.

2.07 BEDDING METHODS

- A. Class A, B, and C Bedding Methods are allowed on this project while the Class D Bedding Method is not allowed. Bedding Methods must comply with the applicable sections of ASTM C 12.
- B. Class A:
 - 1. Complete concrete encasement.
- C. Class B:
 - 1. Pipe is installed on a compacted bed of granular material 6 inches thick.

2. Additional compacted granular material is added around the pipe up to the spring line, or center line.
 3. Additional compacted granular material is added to completely encase the pipe to a depth of 12 inches above the pipe crown.
- D. Class C:
1. Pipe is installed on a 6 inch deep compacted bed of granular material and then an additional granular material up to spring line is added.
- E. Class D: **NOT ALLOWED**

PART 3 EXECUTION

3.01 INSPECTION

- A. Verify stockpiled graded aggregate material to be used in the backfill is approved by Engineer.
- B. Verify areas to be backfilled are free of debris, snow, ice, or water, and surfaces are not frozen.

3.02 PREPARATION

- A. Call Local Utility Line Information service at 811 or 1-800-282-7411 not less than three working days before performing Work. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum locations.
- C. Identify, stake, and flag known below and above grade utilities.
- D. Maintain and protect existing utilities remaining which pass through Work area.
- E. Notify all utility companies prior to grading and where required to remove utilities.
- F. Upon discovery of unknown utility or concealed conditions, discontinue affected work; notify Engineer immediately.
- G. Protect trees, shrubs, lawns, and other landscaping features remaining. Protect benchmarks, right-of-way markers, monuments, iron pins, and property corner markers. Replace disturbed or destroyed landscaping and markers.
- H. Maintain excavated and filled areas in good condition until final acceptance by Owner. Repair damage caused by erosion or other construction operations using materials of same type as damaged material.
- I. Control grading to prevent water running into excavations. Avoid obstruction of surface drainage and employ means to avoid interruption of storm water in existing gutters, other surface drains, or temporary drains.
- J. Provide free access to fire hydrants, water valves, meters, and private drives.

K. Comply with OSHA Construction Standards.

3.03 DEWATERING

- A. Provide and maintain methods to promptly remove and dispose of water entering excavations or other parts of the Work to ensure a dry excavation and preservation of final lines and grades or bottoms of excavations.
- B. Groundwater:
 - 1. Depress and maintain groundwater encountered within the limits of excavation to a minimum elevation of 12 inches below the bottom of the excavation before pipe laying or concreting is started.
 - 2. Do not expose concrete structures to unequal hydrostatic forces until concrete has reached the specified 28-day strength.
 - 3. Do not allow water to rise above bedding during pipe laying operations.
 - 4. Prevent damage to pipelines or structures resulting from floating, undermining, or scour.
 - 5. Commence dewatering when ground or surface water is first encountered and continue until water can safely be allowed to rise in accordance with provisions of this Section.
- C. Excavate and replace foundation soils that are disturbed or loosened by the upward seepage of water or uncontrolled flow of water. Place foundation backfill in bottom of trench to within 6 inches of the bottom pipe. Place 6 inches of bedding stone over the top of the foundation backfill.
- D. Dispose of water from the Work in a suitable manner without damage to adjacent property. Convey water in a manner that does not interfere with construction operations or surrounding property owners. Do not drain water into work built or under construction without prior consent of Engineer. Leave pipe or conduits used for drainage purposes clean and free of sediment.
- E. Control stormwater runoff by means of temporary erosion control methods specified in Section 31 25 13 Erosion Controls, and as indicated on the Drawings, or as directed by Engineer.
- F. Dispose water in a manner that will not be a menace to public health, and in accordance with applicable Environmental Protection Agency, Corp of Engineers, and State of Georgia Environmental Protection Division standards.

3.04 SHEETING, SHORING AND BRACING

- A. Support and maintain excavations with sheeting and shoring as required by federal, state and local safety requirements in order to:
 - 1. Support the sides of excavations.
 - 2. Prevent any movement which could diminish the width of the excavation necessary for proper construction.
 - 3. Protect adjacent structures from undermining or other damage.
 - 4. Protect workers from injury, equipment, utilities, and property from damage.
 - 5. Prevent caving, erosion, and loss of surrounding subsoil.
- B. Leave trench sheeting in place until backfill has been completed to a minimum of twelve inches above the top of pipe. Cut sheeting off at the top of the lowest set of bracing and

remove the upper section unless otherwise directed by Engineer. Refill and ram voids left by sheeting along trenches with suitable tools.

- C. Drive sheeting to depths below bottom of trench or side of excavation in unstable ground as required, ensuring stability.
- D. Underpin adjacent structures damaged by excavation work, including service utilities and pipe chases.
- E. Notify Engineer of unexpected subsurface conditions and discontinue Work in affected area until notified by Engineer to resume Work.
- F. Protect bottom of excavations and soil adjacent to and beneath foundations from frost.
- G. Grade top perimeter of excavation to prevent surface water run-off into excavation.
- H. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.05 TOPSOIL EXCAVATION

- A. Excavate topsoil from areas to be further excavated or graded and stockpile in designated area. Remove excess unused topsoil from site.
- B. Do not excavate wet topsoil.
- C. Stockpile to height not to exceed 8 feet and protect from erosion.

3.06 GENERAL EXCAVATION

- A. Remove all material from an area necessary for the construction structures and provide adequate working spaces and clearance for the Work to be performed therein.
- B. Control excessive dust in or near residential areas caused by excavation operations.
- C. Remove quicksand, soft clay, spongy, swampy, or other unsuitable materials for subgrade or foundation purposes to a level of suitable material as directed by Engineer. Backfill these areas with concrete or with foundation backfill to the original excavation limit or as directed by Engineer.
- D. Warn pedestrians and vehicular traffic of excavations by placing barriers at each end of all excavations and where necessary. Place lights along excavations from sunset to sunrise each day until excavations are backfilled. Prevent people from falling or walking into excavations by barricades.

3.07 BORROW EXCAVATION

- A. Wherever the placement of embankments fills require material not available at the site, suitable material shall be obtained from other sources.

- B. Make arrangements with property owners and pay all costs incident to borrowed material for the use of materials when a borrow pit is opened at a point not immediately accessible to the Work.
- C. Obtain approval of the quality and suitability of materials from Engineer before opening borrow pits. Soil tests required for approval of the borrowed material proposed, shall be at the Contractor's expense.

3.08 TRENCH EXCAVATION

- A. Consist of the removal of materials necessary for the construction of pipelines and all appurtenant facilities including collars, concrete saddles, and pipe protection called for on Drawings.
- B. Excavation for pipelines: Open cut unless otherwise indicated in Drawings.
 - 1. Trenches shall be cut true to lines and grades indicated in Drawings.
 - 2. Cut banks of trenches in vertical, parallel planes equidistant from pipe centerline.
 - 3. When sheeting is used, width of trench shall be considered as distance between the inside faces of the sheeting.
 - 4. Cut bottom of trench to required grade of pipe except where bedding materials or cradles are shown, in which case the excavation shall extend to the bottom of the bedding or cradles as indicated in Drawings.
 - 5. Minimum pipe cover shall be as indicated in Drawings or specified in this Section.
- C. Use of motor-powered trenching machine will be permitted but full responsibility for the preservation, replacement, and/or repair of damage to any existing utility services and private property shall rest with Contractor.
- D. Excavate bell holes for bell and spigot pipe and mechanical joint pipe at proper intervals so the barrel of the pipe will rest for its entire length upon the bottom of the trench or bedding material.
 - 1. Bell holes: Large enough to permit proper installation of all joints in the pipe.
 - 2. Do not excavate bell holes more than 10 joints ahead of pipe laying.
 - 3. No part of any bell or coupling shall be in contact with trench bottom, trench walls, or granular embedment when pipe is jointed.
- E. Excavation for collars, saddles, piers, and other pipeline structures shall conform to additional requirements specified herein for structural excavation.
- F. Pipe trenches shall not be excavated more than 400 feet in advance of pipe laying and all work shall be performed to cause the least possible inconvenience to the public. Adequate temporary bridges or crossings shall be constructed and maintained where required to permit uninterrupted vehicular and pedestrian traffic.
- G. Fill the void thus made to proper grade with concrete or with compacted layers of crushed rock or other material conforming to requirements specified herein for backfill.
- H. Correct any unauthorized excavation.

3.09 SUBSURFACE OBSTRUCTIONS

- A. Do not remove, disturb, or injure any existing water, telephone, gas pipes, storm drainage pipe, headwalls or catch basins, or other conduits or structures, during excavating, backfilling, and laying pipe unless directed by Engineer. Cling, shore up, maintain, and repair structures in operation as necessary.
- B. Provide sufficient notice to utility companies and abide by their regulations before removing or disturbing the utility company's pipes and notify them if any subsurface structures are broken or damaged during execution of the Work.
- C. Repair broken pipes or conduits providing service to adjoining buildings.
- D. Delays such as would result in buildings or residences being without services overnight or for a needlessly long period during the day will not be tolerated. Should it become necessary to move the position of a pipe, conduit or structure, it shall be done by the Contractor in strict accordance with the instructions given by the Engineer or the utility involved.
- E. The Owner or the Engineer will not be liable for any claim made by the Contractor based on underground obstructions being different from that indicated in these contract documents or plans.

3.10 DISPOSAL OF WASTE AND UNSUITABLE MATERIAL

- A. Suitable excavated material shall be used for fill embankments or backfill on the different parts of the Work as required. Remove and dispose of waste materials off site.
 - 1. Waste materials: Materials not used for Work required.
 - 2. Waste materials shall be disposed of at the Contractor's expense.
- B. Remove and dispose of unsuitable materials consisting of rock, wood, vegetable matter, debris, soft or spongy clay, peat, and foreign matter.
- C. Do not dump waste material on private property unless written permission is furnished by owner or property and a permit to dump issued from local jurisdiction.

3.11 ROCK REMOVAL

- A. Rock: Solid mineral material with a volume in excess of 1/2 cu yd that cannot be broken down and removed by use of heavy construction equipment, such as a Caterpillar 215 or equivalent, bulldozer such as a Caterpillar D8K equipped with single tooth hydraulic ripper, 3/4 cu yd capacity power shovel, rooters, etc., and without drilling or blasting. Materials which can be loosened with a pick, hard pan, boulders less than 1/2 cu yd in volume, chert, clay, soft shale, soft and disintegrated rock and any similar material shall not be considered as rock. All materials to be considered unclassified or common excavation.
- B. Remove rock materials discovered during excavation for the purpose of construction using mechanical methods.
- C. Explosive methods for rock removal shall only be allowed with prior approval from Engineer. Notify Engineer if explosives are required for rock removal.

3.12 BEDDING

- A. Contractor may submit a sieve analysis of locally available material to be substituted for the specified material. However, written approval from the Engineer must be obtained before such material can be used.
- B. Bedding shall be placed under and around the pipe and shall be sufficiently compacted to support the pipe when the trench is backfilled.
- C. Use Class "B" bedding in all wet trench conditions, under driveways, and pavements. Use Class "C" bedding in trenches where rock is encountered. Class "C" Bedding shall be used in all other areas.

3.13 FILLS AND EMBANKMENTS - COMMON FILL

- A. Fills and embankments: All earth fills except backfills in trenches or around structures.
- B. Place materials in fill or embankment in successive layers of 8 inches or less thickness before compaction, each layer being approximately horizontal and extending to a fill limit of required cross section.
- C. Common fill shall be compacted to at least 95 percent of maximum density as determined by ASTM D698.
- D. Materials placed in fill areas shall be deposited to the lines and grades shown on the Drawings making due allowance for settlement of the material and for the placing of loam thereon.
- E. The surfaces of filled areas shall be graded to smooth true lines, strictly conforming to grades indicated on the grading plan and no soft spots or uncompacted areas will be allowed in the work.
- F. No compacting shall be done when the material is too wet either from rain or from excess application of water. At such times, work shall be suspended until the previously placed and new materials have dried sufficiently to permit proper compaction.

3.14 BACKFILL AROUND STRUCTURES

- A. Start backfill of structures immediately after construction has been approved by Engineer.
- B. Backfill material shall be as specified in this Section.
 - 1. Material that is too dry for adequate compaction shall receive a prior admix of water to achieve optimum moisture content.
 - 2. Material having excessive water content shall not be placed at any time.
 - 3. Backfill material shall be free of large clods, rocks, vegetable matter, debris, and/or other objectionable material.
 - 4. It shall be deposited in horizontal layers not to exceed 6 inches in thickness (before compaction) on each side of the structure.
 - 5. Each layer shall be thoroughly tamped or rammed with approved power driven tools until the required density is achieved.

- C. All backfilling shall be done in such a manner that the structure over or against which it is being placed will not be disturbed or injured. Any structure injured, damaged or moved from its proper line or grade during backfilling operations shall be removed and repaired to the satisfaction of Owner and then re-backfilled.
- D. Backfilling shall not be done in freezing weather except by permission of the Engineer, and shall not be done with frozen material or upon frozen materials.
- E. All backfilling shall be left with smooth, even surfaces, properly graded and shall be maintained in this condition until final completion and acceptance of the work. Where directed by the Engineer, the backfill shall be mounded slightly above the adjacent ground.
- F. Leave stockpile areas completely free of excess fill materials. After construction and cleanup, stockpile areas shall be seeded in accordance with Section 32 92 19.
- G. Minimum cover over a gravity sewer shall be 36-inches. If the soil cover is less than 36-inches, then a high strength pipe shall be used such as ductile iron pipe.

3.15 TRENCH BACKFILL

- A. Start backfilling of trenches immediately after construction has been viewed by Engineer.
 - 1. Backfill material shall be as specified in this Section.
 - 2. Material that is too dry for adequate compaction shall receive a prior admix of water to achieve optimum moisture content.
 - 3. Material having excessive water content shall not be placed at any time.
 - 4. Backfill material shall be free of large clods, rocks, vegetable matter, debris, and/or other objectionable material.
 - 5. Deposit in horizontal layers not to exceed 6 inches in thickness (before compaction) on each side of the pipe.
 - 6. Each layer shall be thoroughly tamped or rammed around the pipe with approved power driven tools until enough material has been placed and compacted to provide a cover of not less than 12 inches over top of pipe.
- B. In all other areas not affected by superimposed loads, Class IV backfill may be placed from the level 12 inches above top of pipe upward with sufficient compaction to prevent future settlement in the areas of excavation, unless otherwise indicated on the Drawings. At these places, backfill shall be neatly rounded over the trench to sufficient height to allow for settlement to grade after consolidation.
- C. All backfilling shall be done in such a manner that the pipe or structure over or against which it is being placed will not be disturbed or injured. Any pipe or structure injured, damaged or moved from its proper line or grade during backfilling operations shall be removed and re-laid to the satisfaction of Owner and then re-backfilled.
- D. Backfilling shall not be done in freezing weather except by permission of the Engineer, and shall not be done with frozen material or upon frozen materials.
- E. All backfilling shall be left with smooth, even surfaces, properly graded and shall be maintained in this condition until final completion and acceptance of the work. Where directed by the Engineer, the backfill shall be mounded slightly above the adjacent ground.

- F. Leave stockpile areas completely free of excess fill materials. After construction and cleanup, stockpile areas shall be seeded in accordance with provisions specified in Section 32 92 19.
- G. Minimum cover over gravity sewer shall be 36-inches. If the soil cover is less than 36-inches, then a high strength pipe shall be used such as ductile iron pipe. Minimum cover over force main shall be 48-inches.

3.16 EMBANKMENTS OVER SEWERS, LATERALS, OR PIPES

- A. Cover and protect by an embankment where the crown of a pipe comes to or extends above the surface of the ground.
 - 1. Unless otherwise ordered or indicated on the Drawings, this embankment shall be at least three (3) feet deep over the top of the pipe, at least two (2) feet wide at the top, and with side slopes of not less than three horizontal to one vertical extending to the surface of the ground.
 - 2. Make provisions for surface drainage.
- B. Use materials free from all perishable matter and refuse, such as scraps of forms, wire, brush, or any foreign materials. Do not use ashes, large stones, muck, or other soft materials.
- C. Place earth in layers not exceeding twelve (12) inches in thickness, and compact by hand tamping, or by other methods directed by the Engineer.
- D. Do not build embankments during freezing weather nor with frozen materials.
- E. Bring surface to the true lines and grades as specified or indicated on the Drawings, rake smooth and leave free from rubbish, stones, or gravel.
- F. Place fill or embankment over and around structures evenly on all sides to avoid unbalanced loading or overturning action.

3.17 BACKFILL UNDER PAVING

- A. City or County Road Right-of-Ways:
 - 1. Conform to GDOT standards and specifications for replacement during construction.
- B. Department of Transportation Right-of-Ways:
 - 1. Conform to GDOT standards and specifications for replacement during construction.

3.18 TESTING

- A. In accordance with ASTM D-698.
- B. Compacted to 98% in streets and 95% elsewhere of maximum density at optimum moisture content.
- C. Each 12 inches of lift of select backfill shall be tested at random with an average grid spacing of 100 feet. Test each 12 inches of lift of granular backfill at random with an average spacing of 200 feet along the route line of the trench. Furnish a copy of the compaction report for trenches in or close to an existing roadbed.
- D. Trenches across driveways shall be tested once for each lift at the center of the drive.

- E. Road crossings shall be tested once per lift for each lane of traffic.
- F. For small backfill areas a minimum of two (2) tests shall be performed for each structure subgrade and one for each side of the structure that is backfilled.
- G. Cut areas shall have the top six (6) inches of material proof rolled and compacted to 98% of maximum density.
- H. Fill areas shall have the top twelve (12) inches proof rolled and compacted to 98% of maximum density. Areas not meeting the required compaction shall be re-compacted until the desired degree of compaction is achieved.
- I. All testing must be coordinated and reviewed by the Engineer.
- J. Proof roll with a single heavy dump truck filled with dirt (12 tons minimum), fully loaded scraper or a heavy rubber tired roller as recommended by the Engineer. Excavate, refill, re roll and re test areas showing sponginess or pumping to remove unsuitable material.
- K. Areas not meeting the required compaction shall be recompacted until the desired degree of compaction is achieved.

3.19 GRADING

- A. Final grading shall be performed to achieve a product in strict conformance with the final grades and contours required on the Contract Drawings with a vertical and horizontal tolerance with one tenth of one foot.

3.20 SETTLEMENT

- A. Contractor shall be responsible for all settlement of backfill, fills, and embankments which may occur during the one (1) year warranty period.
- B. Make necessary repairs or replacements caused by settlement within 30 days after receipt of written notice from Engineer or Owner.

END OF SECTION

SECTION 31 10 00

SITE CLEARING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Removing surface debris.
 - 2. Removing designated paving and curbs.
 - 3. Removing designated trees, shrubs, and other plant life.
 - 4. Excavating topsoil.
- B. Related Sections:
 - 1. Section 02 41 16 – Structure Demolition: Removing underground storage tanks and designated utilities.
 - 2. Section 31 00 00 – Earthwork.
 - 3. Section 31 25 13 – Erosion Controls.

1.02 DEFINITIONS

- A. Clearing: The removal and disposal of all exposed objectionable matter such as: trees, brush, logs, buildings, fences, poles, rubbish, loose boulders and other debris resting on or protruding through the ground surface.
- B. Grubbing: The removal and disposal of all objectionable matter such as: logs, poles, stumps, structures, boulders, rubbish, and other debris which is embedded in the soil.
- C. Topsoil: The top loamy soil and organic matter that overlays the subsoil.

1.03 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit data for herbicide. Indicate compliance with applicable codes for environmental protection.

1.04 QUALITY ASSURANCE

The Contractor, in conducting the work required on this project, is to cause little or no damage to the soils and vegetation outside the limits of construction defined in this and other sections of these Specifications, as shown on the Drawings, or required by the Engineer. Any damage to soil or vegetation outside of the limits of construction shall be repaired immediately by the Contractor as defined herein at no additional cost to the Owner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify existing plant life designated to remain is tagged or identified.
 - 1. Contractor to lay out area to be cleared and have inspected by the Engineer before work is started.
- C. Identify waste area for placing removed materials.

3.02 PREPARATION

- A. Call Local Utility Line Information service at 811 not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.

3.03 PROTECTION

- A. Locate, identify, and protect utilities indicated to remain, from damage.
- B. Protect trees, plant growth, and features designated to remain, as final landscaping as specified in Section 01 50 00 - Temporary Facilities and Controls.
- C. Protect bench marks, survey control points, and existing structures from damage or displacement.

3.04 CLEARING

- A. Contain limits of clearing within construction limits as indicated on Drawings, right-of-way, and easements.
- B. Remove trees and shrubs indicated. Remove stumps, main root ball, and surface rock.
- C. Clear undergrowth and deadwood, without disturbing subsoil.
- D. Apply herbicide to remaining stumps to inhibit growth.

3.05 REMOVAL

- A. Remove debris, rock, and extracted plant life from site.
- B. Partially remove paving and curbs as indicated on the Contract Drawings. Neatly saw cut edges at right angle to surface.

- C. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.
- D. Do not burn or bury materials on site. Leave site in clean condition.

3.06 TOPSOIL EXCAVATION

- A. Excavate topsoil from marked areas, without mixing with foreign materials for use in finish grading.
- B. Do not excavate wet topsoil.
- C. Stockpile in area designated on site to depth not exceeding 8 feet and protect from erosion. Stockpile material until disposal.
- D. Remove excess topsoil not intended for reuse, from site.

END OF SECTION

SECTION 31 23 18

ROCK REMOVAL

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Removal of all rock materials discovered during excavation for the purpose of construction. Removal shall include drilling and/or blasting incidental thereto and disposal of excavated materials.
- B. When necessary for prosecution of the WORK, the use of explosives to assist rock removal may be exercised by CONTRACTOR provided this use is in compliance with all local, State, Federal and other Governmental regulations applying to transportation, storage, use and control of explosives.

1.02 RELATED WORK

- A. Section 31 00 00 - Earthwork

1.03 REFERENCES

- A. NFPA 495 - Code for the Manufacture, Transportation, Storage, and Use of Explosive Materials.
- B. OSHA 2207 - Construction Industry Standards, Subpart T - Demolition.

1.04 QUALITY ASSURANCE

- A. Explosives Firm: Company specializing in explosives for disintegration of subsurface rock with documented experience.

1.05 REGULATORY REQUIREMENTS

- A. Conform to applicable code for explosive disintegration of rock.
- B. Obtain permits from authorities having jurisdiction before explosives are brought to site or drilling is started.
- C. All explosives shall be stored securely in compliance with all laws and ordinances, and all such storage places shall be clearly marked DANGEROUS EXPLOSIVES. Blasting caps, electric blasting caps, detonating primers, and primed cartridges shall not be stored in the same magazine with other explosives or blasting agents. Locked storage shall be provided satisfactory to the ENGINEER, never closer than 1000 feet from any road, building, or camping area.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Rock (Definition): Solid mineral material with a volume in excess of 1/2 cu yd that cannot be broken down and removed by use of heavy construction equipment, such as a Caterpillar 215 or equivalent, bulldozer such as a Caterpillar D8K equipped with single tooth hydraulic ripper, 3/4 cu yd capacity power shovel, rooters, etc., and without drilling or blasting. Materials which can be loosened with a pick, hard pan, boulders less than 1/2 cu yd in volume, chert, clay, soft shale, soft and disintegrated rock and any similar material shall not be considered as rock. (All materials to be considered unclassified or common excavation)
- B. Explosives: Shall be suitable for intended purposes at the CONTRACTOR's option subject to review by OWNER and ENGINEER.
- C. Delay Devices: Type recommended by explosives firm to be used as accessory to explosives. Subject to review by ENGINEER.
- D. Blasting Mat: When the use of explosives is necessitated during prosecution of the WORK, CONTRACTOR shall incorporate the use of blasting mats of type recommended by explosives firm to lessen the danger of projectiles occasionally resultant from blasting of rock.

PART 3 EXECUTION

3.01 INSPECTION

- A. CONTRACTOR shall verify site conditions and note irregularities affecting work of this Section prior to performing any operations involving explosives. CONTRACTOR shall submit to OWNER for review a detailed plan for using explosives to include, but not limited to:
 - 1. Blasting is to be performed by a reputable firm with experience.
 - 2. Sequence of WORK
 - 3. Equipment
 - 4. Protection to be provided for existing structures to remain
 - 5. Personnel
 - a. Training
 - b. Previous experience with the use of explosives in similar situation
- B. Beginning work of this Section means acceptance of existing condition.
- C. Rock in utility trenches shall be excavated over the horizontal limits of excavation and to depths as follows:

Size of Pipeline (Inches)	Depth of Excavation Below Bottom of Pipe (Inches)
Less than 4	6
4 to 6	8
Over 8	12

Space below grade for pipe shall then be backfilled with minus 3/4-inch crushed rock or gravel or other approved materials and tamped to proper grade.

3.02 ROCK REMOVAL - MECHANICAL METHOD

- A. Excavate for and remove rock by the mechanical method.
- B. Where pipes are constructed on concrete cradles, rock shall be excavated to bottom of cradle as shown on plans.
- C. Where rock foundation is obtained at grade for over 50 percent of area of any one structure, the portion of foundation that is not rock shall be excavated below grade to reach a satisfactory foundation of rock. The portion below grade shall be backfilled with Class A concrete (3,000psi @28 days).
- D. Where rock foundation is obtained at grade for less than fifty (50%) of any one structure and satisfactory rock cannot be found over the remaining area by reasonable additional excavation, the rock shall be removed for a depth of twelve (12) inches below grade and the space below grade shall be backfilled with crushed stone as specified for pipelines.
- E. Rock excavation near existing pipelines or other structures shall be conducted with utmost care to avoid damage. Injury or damage to other structures and properties shall be promptly repaired to the satisfaction of OWNER and by CONTRACTOR at his own expense.
- F. Rock excavation for all structures and adjacent trenches under this Contract and any other rock excavation directed by OWNER shall be completed before construction of any structure is started in the vicinity.
- G. Remove excavated material from site.
- H. The CONTRACTOR shall correct unauthorized rock removal by backfill to grade with Class A concrete in accordance with backfilling and compaction requirements of Section 31 00 00 (Earthwork) at his own expense.

3.03 ROCK REMOVAL - EXPLOSIVES METHODS

- A. If rock is uncovered requiring the explosives method for rock disintegration and removal, the ENGINEER shall be notified immediately so that the surface can be examined. Blasting will not be permitted unless written authorization is given by ENGINEER. (All materials removed shall be considered common excavation).
- B. The CONTRACTOR shall notify any owners of adjacent buildings or structures, and any public utility owners having structures or other installations above or below ground, in writing prior to use of explosives. Such notice shall be given sufficiently in advance so that they may take such steps as they may deem necessary to protect their property from injury and/or damage.
- C. Rock excavation by use of explosives shall be conducted with due regard for safety of persons and property in the vicinity and in strict conformance with requirements of local, State and Federal ordinance, laws and regulations governing the use of explosives.

- D. Blasting shall be conducted so as not to endanger persons or property, and whenever required, the blast shall be covered with mats or otherwise satisfactorily confined. The CONTRACTOR shall be held responsible for and shall make good any damage caused by blasting or accidental explosions.
- E. The CONTRACTOR shall permit only authorized and qualified persons to handle and use explosives.
- F. Smoking, firearms, matches, open flame lamps, and other fires, flame or heat producing devices and sparks shall be prohibited in or near explosive magazines or while explosives are being handled, transported or used.
- G. No person shall be allowed to handle or use explosives while under the influence of intoxicating liquors, narcotics, or other dangerous drugs.
- H. All explosives shall be accounted for at all times. Explosives not being used shall be kept in a locked magazine, unavailable to persons not authorized to handle them. The CONTRACTOR shall maintain an inventory and use record of all explosives. Appropriate authorities shall be notified of any loss, theft, or unauthorized entry into a magazine.
- I. No explosives or blasting agents shall be abandoned.
- J. CONTRACTOR's employees authorized to prepare explosive charges or conduct blasting operations shall use every reasonable precaution including, but not limited to, visual and audible warning signals, flags, or barricades, to ensure safety.
- K. It shall be CONTRACTOR's responsibility to incorporate the use of seismic monitoring should rock excavation, by use of explosives, occur within 150 feet of any residential structure and within 300 feet of any miscellaneous structure. Blasting conducted near dams or bridge foundations shall incorporate the use of a seismic monitor should such blasting occur within 25 feet of said dam and/or bridge foundation. CONTRACTOR shall maintain all seismic records and blasting logs to be furnished to ENGINEER upon request.
- L. Disintegrate rock and remove from excavation.
- M. Cut away rock at excavation bottom to form level bearing.
- N. Remove shaled layers to provide sound and unshattered base for pipe foundations.
- O. Remove excavated material from site.
- P. Correct unauthorized rock removal or overbreak in accordance with backfilling and compaction requirements at his own expense.

3.04 FIELD QUALITY CONTROL

- A. Provide for visual inspection of bearing surfaces and cavities formed by removed rock for inspection by ENGINEER or his representative prior to laying of pipe.

END OF SECTION

SECTION 31 25 13

EROSION CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Construction Exit.
2. Temporary Sediment Barrier (Silt Fence).
3. Temporary Sediment Barrier (Hay Bales).
4. Rip Rap.
5. Mulching.
6. Temporary Grassing.
7. Permanent Grassing.
8. Fertilizer.

B. Scope of Work:

1. Erosion control measures shall be designed for a 25-year, 24-hour rain event.
2. Erosion control shall be employed during the construction period and shall include all measures required to prevent soil erosion from the site until permanent erosion control measures are installed. Work shall be accomplished through, but not limited to, the use of berms, dikes, sediment barriers, sediment traps, sediment basins, silt fences, temporary grasses, check dams, mulching, construction exits and slope drains.
3. Erosion control measures described herein shall be continued until such time as permanent planting and restoration of natural areas is effectively in control of erosion from project site.
4. Failure to install and maintain temporary erosion control measures throughout the construction period may be cause to halt construction by governing authorities until such measures are correctly installed and operational.

C. Related Sections:

1. Section 03 10 00 - Concrete Forming and Accessories.
2. Section 03 20 00 - Concrete Reinforcing.
3. Section 03 30 00 - Cast-In-Place Concrete.
4. Section 31 00 00 - Earthwork.
5. Section 31 10 00 - Site Clearing.
6. Section 31 37 00 – Riprap.
7. Section 32 92 19 – Seeding.
8. Section 32 92 23 – Sodding.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

- B. Contractor shall comply with applicable codes, rules, ordinances, regulations, and laws of local, municipal, state or federal authorities having jurisdiction over project.

- C. "Manual for Erosion and Sediment Control in Georgia" published by the State Soil and Water Conservation Committee of Georgia – Current Edition.
- D. State of Georgia Erosion and Sedimentation Control Act of 1975, current amendment.

1.03 SUBMITTALS

- A. Submit proposed schedule for installation, maintenance and removal of all temporary and permanent erosion and sediment control measures. The schedule should reflect the requirements below and show the anticipated starting and completion dates for all land development activities including:
 - 1. Installation of temporary and permanent sediment control structures.
 - 2. Stormwater management facilities.
 - 3. Timber salvage operations.
 - 4. Clearing operations.
 - 5. Grubbing operations.
 - 6. Rough and finished grading.
 - 7. Building construction.
 - 8. Landscaping, including all seeding and sodding.
 - 9. Removal of temporary sediment control structures.

1.04 QUALITY ASSURANCE

- A. Perform Work in accordance with "Manual for Erosion and Sediment Control in Georgia" published by the State Soil and Water Conservation Committee of Georgia – Current Edition.

1.05 PRE-INSTALLATION MEETINGS

- A. Section 01 30 00 - Administrative Requirements.
- B. Convene minimum one week prior to commencing work of this section.

1.06 SEQUENCE OF CONSTRUCTION OF TEMPORARY SEDIMENT CONTROL MEASURES

- A. Install all erosion and sediment control structures specified herein and shown in the Contract Documents, or as directed by the Engineer, as the first item of work within a given drainage area. Construction and installation of all sediment control structures shall begin downgradient of the area to be disturbed and proceed upgradient. Contractor shall at all times maintain all soil erosion and sediment control structures and practices throughout construction and until permanent grass cover is established.

PART 2 PRODUCTS

2.01 CONSTRUCTION EXIT

- A. Rock: Granite type; crushed irregular shaped stone; solid and nonfriable; 1.5 inch minimum size, 3.5 inch maximum size.

- B. Geotextile Fabric: Furnish in accordance with State of Georgia Department of Transportation standards.
- C. Construct as indicated on Drawings.

2.02 TEMPORARY SEDIMENT BARRIERS (SILT FENCE)

- A. Filter fabric for silt fences shall be pervious synthetic polymer filaments forming a stable network so that fibers retain their relative positions. Filter fabric shall be of the type recommended by its manufacturer for the intended application. The filter fabric shall meet the following requirements:
 - 1. Minimum Grab Strength: 150 lbs. (by ASTM D1682)
 - 2. Elongation: 25%
 - 3. Retention Efficiency: 75%
- B. Silt fence shall be constructed in accordance with details shown on Drawings or may be a prefabricated proprietary type subject to approval by Engineer.

2.03 TEMPORARY SEDIMENT BARRIERS (HAY BALES)

- A. Hay bales shall be well compacted straw, standard size, wire bound. Hay bales may be used as an alternate to silt fence as approved by Engineer.

2.04 RIP RAP

- A. Riprap: Granite or Limestone type; irregular shaped rock; solid and nonfriable; 5 inch minimum size, 12 inch maximum size. Construct as indicated on Drawings.

2.05 MULCHING (DS1)

- A. Spread dry straw or hay, free of weeds and seeds, at 2-1/2 tons per acre.
- B. Spread wood waste, chips, sawdust, or bark, 2 to 3 inches deep (6 to 9 tons per acre).
- C. Apply erosion control matting or netting according to manufacturer's requirements or recommendations.

2.06 TEMPORARY GRASSING (DS2)

- A. Grass seed for temporary erosion control shall be applied at the rates and dates indicated in the following table:

Species	Rate per 1,000 sq ft	Rate per acre	Planting Dates		
			Mountains Limestone Valley	Piedmont	Coastal
Rye	4.0 lbs	3 bushels	July 15 - Dec 1	Aug 15 - Jan 1	Sep 1 - Mar 1
Ryegrass	1.0 lbs	40 lbs	Aug 1 - May 1	Aug 1 - Apr 15	Aug 15 - Apr 1
Weeping Lovegrass	0.1 lbs	4 lbs	Mar 15 - Jun 15	Mar 15 - Jun 15	Feb 15 - Jun 15

Sudangrass	1.4 lb	60 lbs	Apr 1 – Sep 1	Apr 1 – Sep 1	Mar 1 – Aug 1
Browntop Millet	1.0 lb	40 lbs	Apr 1 – Jul 1	Apr 1 – Jul 1	Apr 1 – Jul 1
Wheat	4.0 lbs	3 bushels	Sep 1 – Jan 1	Sep 1 – Jan 1	Sep 15 – Feb 1

- B. Install Work in accordance with "Manual for Erosion and Sediment Control in Georgia" published by the State Soil and Water Conservation Committee of Georgia - Current Edition.

2.07 PERMANENT GRASSING (DS3)

- A. Grass seed for permanent erosion control in accordance with details shown on Drawings.
- B. Maintain seeded areas until Work is complete.
- C. Mow at least four weeks apart during growing season.

2.08 FERTILIZER

- A. Commercial grass fertilizer with a 10N-10P-10K proportion.
- B. Agricultural lime to be applied at a rate of one (1) ton per acre.

PART 3 EXECUTION

3.01 GENERAL

- A. Temporary erosion control shall be directed toward and have the purpose of controlling soil erosion at its potential source. Downstream sediment entrapment measures shall be employed, but only as a backup to primary control at the source.
- B. A continuing program of installation and maintenance of sediment control measures shall be employed during the construction period.
- C. Erosion Control Schedule:
 1. Prior to the pre-construction conference, Contractor shall submit to the Engineer his proposed erosion control plan for the project in accordance with requirements of this section. The plan shall be based on an analysis of the project conditions and shall be in written form. This plan shall specifically indicate the sequence of clearing and grubbing, earthwork operations, including trenching and backfilling, construction of permanent erosion control features and the proposed uses of temporary erosion control features.
 2. Plan shall also include proposed methods to prevent pollution of streams, lakes and rivers and other water resources.
 3. Contractor shall outline his proposed methods of controlling erosion and preventing pollution on public and construction access roads, staging areas and waste disposal areas.
 4. No work shall be started until the aforementioned plans have been approved by Engineer. Contractor will be responsible for accomplishment of work in accordance with approved plans. Engineer may approve changes made necessary by unforeseen circumstances which are beyond the control of Contractor.

- D. Owner and Engineer have the authority to limit the surface area of erodible earth materials exposed by clearing and grubbing, the surface area of erodible earth exposed by excavation and backfill operations and to direct Contractor to provide immediate permanent or temporary erosion and pollution control measures to prevent contamination of adjacent streams or other water courses.
- E. Clearing and grubbing operations shall be so scheduled and performed that grading operations and permanent erosion control features can immediately follow thereafter, if the project conditions permit, otherwise temporary erosion control measures will be required between successive construction stages.
- F. Owner and Engineer will require Contractor to limit the area of excavation, trenching and pipe laying operations in progress commensurate with Contractor's capability and progress in keeping finish grading, mulching, seeding and other permanent and/or temporary measures current with accepted schedule.

3.02 TEMPORARY GRASSING AND MULCHING

- A. Where staged construction or other conditions beyond the control of the Contractor prohibit the completion of work in a continuous manner, Owner and Engineer may order Contractor to apply temporary seeding or temporary mulch to an erodible area.
- B. Temporary grass shall consist of sowing a quick growing species of grass suitable to the area and season. Seeding rates shall be in accordance with Paragraph 2.6. Ground preparation will be limited to blading the area to the amount deemed practical by the Owner and Engineer for a seed bed and the elimination of water pockets. Fertilizer shall be applied at a rate of 14 pounds per 1,000 square feet.
- C. Areas to be mulched need not be to finished grade. The mulched areas may be placed on slopes as steep as 2:1 using a tractor to imbed the mulch into the slope.
- D. Spread wood waste uniformly on slopes that are 3:1 and flatter. No anchoring is needed.
- E. Commercial matting and netting. Follow manufacturer's specifications included with the material.

3.03 SEDIMENT TRAPS

- A. Install sediment traps in accordance with details shown on Drawings.
- B. Sediment traps shall be maintained until other erosion control methods can be substituted for them.
- C. Sediment traps shall be cleaned out when they are 1/2 filled with silt.
- D. Sediment traps shall be removed from the construction area when their use is no longer required.

3.04 RIP RAP

- A. Place geotextile fabric over substrate, lap edges and ends.

- B. Place riprap at culvert pipe ends, at embankment slopes, and as indicated on Drawings.

3.05 SILT FENCE

- A. Temporary silt fences shall be located at all points where surface water can leave the construction area.
- B. Silt fences shall be installed so as to remove sediments from flowing water through filtration and sedimentation. Silt fences shall be installed in accordance with the details shown on Drawings.
- C. Silt fences shall be arranged to create ponding behind them. Provision shall be made for removing accumulated sediments and maintaining ponding capacity.
- D. Silt fences shall be removed and the area restored when permanent vegetation or other erosion control measures are effective.

3.06 GRADING OPERATIONS

- A. Grading operations shall be scheduled so that ground surface will be disturbed for the shortest possible time before permanent construction is installed. Large areas shall be maintained as flat as possible to minimize soil transport through surface flow.
- B. Wherever steep slopes or abrupt changes in grade are required, a diversion or berm shall be constructed at the top of slope to cause surface water to flow along the diversion to a control point to be transported downslope in a slope drain. In no case shall surface water be allowed to flow uncontrolled down slopes.

3.07 CONSTRUCTION IN STREAM BEDS

- A. Unless otherwise approved in writing by Engineer, construction operations in rivers, streams and impoundments shall be restricted to those areas which must be entered for the construction of temporary or permanent structures. As soon as conditions permit, rivers, streams and impoundments shall be promptly cleared of all false-work, sheeting or piling, which are to be removed, debris and other obstructions. Fording of live streams with construction equipment will not be permitted; therefore, temporary bridges or other structures (stream crossings) shall be used whenever stream crossings are required. Unless otherwise approved in writing by Engineer, mechanized equipment shall not be operated in live streams except as may be required to construct channel changes and temporary or permanent structures, and to remove temporary structures.

3.08 RUN-OFF EROSION AND SEDIMENTATION CONTROLS

- A. During construction, route run-off through sedimentation barriers and check dams as practical.
- B. Contractor shall maintain sedimentation devices in functional condition. Sedimentation barriers and check dams shall be cleaned out when these devices are at least 60 percent of their capacity. Defective materials in barriers and check dams shall be replaced.

- C. Contractor shall establish sedimentation barriers at the toe of slopes under construction. These barriers may be relocated and reused after permanent slope stabilization becomes established. As they are relocated, any defective materials shall be replaced. In addition, all debris and silt at previous location will be removed.
- D. A 6-inch minimum thickness of crushed stone construction exit pad shall be located at all access points to site from public streets in accordance with details shown on the Contract Drawings. All construction vehicles leaving construction site shall have mud cleaned from their tires at these points to protect public streets from the transportation of sediment from site.

3.09 CLEANING

- A. When sediment accumulation in sedimentation structures has reached a point one-third depth of sediment structure or device, remove and dispose of sediment.
- B. Do not damage structure or device during cleaning operations.
- C. Do not permit sediment to erode into construction or site areas or natural waterways.
- D. Clean channels when depth of sediment reaches approximately one half channel depth.

END OF SECTION

SECTION 31 37 00

RIP RAP

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This section pertains to the use of rip rap for the protection of rivers, creeks and ditches from the effects of erosion and scouring. The work required consists of all materials, accessories, equipment, tools and labor required to install rip rap.

1.02 REFERENCES

- A. Manual for Erosion and Sediment Control in Georgia.

PART 2 PRODUCTS

2.01 RIP RAP

- A. All stone for rip rap shall conform to the following tables for the type specified on the Contract Drawings:

TABLE NO. 1
GRADED RIP RAP STONE

Type	Screen Size inches (Sq. opening)			Common Uses	Filter Stone ASTM D-448
	MAX.	AVG.	MIN.		
3	12	9	5	Creek Banks Pipe Outlets	6 or 57
1	24	12	7	Lakes & Shorelines, Rivers	3, 4 or 5

2.02 FILTER BEDDING STONE

- A. Materials used for filter bed stone shall conform to the following table.

FILTER BEDDING STONE

ASTM D-448 TABLE 1	Normal Sizes (inches)
3	2" - 1"
4	1 1/2"-3/4"
5	1" - 1/2"
6	3/4"-3/8"
57	1" - No. 4

2.03 GEOTECHNICAL FILTER FABRIC

- A. As an alternate to filter bedding stone, the contractor may use geotechnical filter fabric. Use must be approved by the Engineer prior to installation.
- B. Filter fabric shall have strength and engineering properties that meet or exceed those of MIRAFI 700X or PROPEX 1199, or be an equivalent approved by the Engineer.

2.04 ALTERNATE MATERIAL

- A. Sand cement bag. Sand and Portland Cement shall be mixed at the maximum ratio of 5:1 by weight, and shall obtain a minimum compressive strength of 500 psi in 7 days. For Sand-Cement Bag Rip Rap, the amount of water used shall be just enough to make up the optimum moisture content of the aggregate and cement.
- B. Sound concrete. Concrete may be used in place of stone if it is broken into the sizes specified for graded rip rap stone.

2.05 LOCALLY EXCAVATED ROCK

- A. Rock excavated from the site may be used for work described under this section, provided that the quality and size requirements meet the requirements of Articles 2.01 and 2.02.

2.06 MATERIAL AVAILABILITY

- A. The gradation of stone sizes listed in these tables are guidelines. Individual quarries may produce different gradations depending on local conditions. If gradations are different from those listed, contractor is to notify the ENGINEER for approval prior to use on the project.

PART 3 EXECUTION

3.01 STONE OR CONCRETE RIP RAP

- A. Prepare area to receive rip rap. Ensure area is sufficiently stable and compacted to receive the stone.
- B. Install either filter stone to thicknesses specified on drawings, or geotechnical filter fabric per manufacturer's recommendations.
- C. Upon completion of the filter bed preparation, the rip rap shall be dumped and handled into place to form a compact layer to a thickness as shown on the drawings. Tolerance for rip rap shall be plus 6 inches, with no under-tolerance permitted.

3.02 SAND BAG RIP RAP

- A. When Sand-Cement Rip Rap is to be pre-bagged, the sand cement shall be mixed dry, and after placing each course, the bags shall be wet until sufficient moisture is present for proper cement hydration.

- B. Placement: The bags shall be uniformly filled to the maximum capacity which will permit satisfactory tying. The bagged Rip Rap shall be placed by hand with the tied ends facing the same direction, with close, broken joints. When directed by the ENGINEER or required by the plans, header courses shall be placed. After placing, the bags shall be rammed or packed against one another to produce the required thickness and form a consolidated mass. The top of each bag shall not vary more than 3 inches above or below the required plane.

3.03 CLEAN-UP

- A. After installation is complete, the area surrounding the rip rap shall be cleared of all debris.
- B. Grassing or mulch stabilization is to be installed on all disturbed areas after clean-up is complete.

END OF SECTION

SECTION 32 11 23

AGGREGATE BASE COURSES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Aggregate subbase.
 - 2. Aggregate base course.
- B. Related Sections:
 - 1. Section 31 00 00 - Earthwork.
 - 2. Section 31 37 00 - Riprap.
 - 3. Section 32 12 16 - Asphalt Paving: Binder and finish asphalt courses.
 - 4. Section 32 13 13 - Concrete Paving: Finish concrete surface course.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.
- B. ASTM International:
 - 1. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - 2. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 3. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 4. ASTM D2940 - Standard Specification for Graded Aggregate Material For Bases or Subbases for Highways or Airports.
 - 5. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.03 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Product Data:
 - 1. Submit data for geotextile fabric and herbicide.

1.04 QUALITY ASSURANCE

- A. Furnish each aggregate material from single source throughout the Work.
- B. Materials shall be in accordance with Georgia DOT Standard Specifications Section 817.01.

PART 2 PRODUCTS

2.01 AGGREGATE MATERIALS

- A. Subbase Aggregate: ASTM D2940; graded type.

Sieve Size	Percent Passing
2 inches	100
No. 4	30 to 60
No. 200	0 to 12

- B. Base Aggregate: ASTM D2940; graded type.

Sieve Size	Percent Passing
2 inches	100
1-1/2 inches	95 to 100
3/4 inches	70 to 92
3/8 inches	50 to 70
No. 4	35 to 55
No. 30	12 to 25
No. 200	0 to 8

PART 3 EXECUTION

3.01 EXAMINATION

- A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify compacted substrate is dry and ready to support paving and imposed loads.
1. Proof roll substrate with in minimum two perpendicular passes to identify soft spots.
 2. Remove soft substrate and replace with compacted fill as specified in Section 31 00 10.
- C. Verify substrate has been inspected, gradients and elevations are correct.

3.02 PREPARATION

- A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.

- B. Do not place fill on soft, muddy, or frozen surfaces.

3.03 AGGREGATE PLACEMENT

- A. Place aggregate equal thickness layers to total compacted thickness of inches indicated on Drawings.
 - 1. Maximum Layer Compacted Thickness: 6 inches.
 - 2. Minimum Layer Compacted Thickness: 3 inches.
- B. Roller compact aggregate to 95 percent maximum density.
- C. Level and contour surfaces to elevations, profiles, and gradients indicated.

3.04 FIELD QUALITY CONTROL

- A. Section 01 40 00 - Quality Requirements
- B. Section 01 70 00 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- C. Compaction testing will be performed in accordance with ASTM D698 for driveways and AASHTO T180 for all roads.
- D. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.
- E. Frequency of Tests: One test for every 1000 square yards compacted aggregate.

3.05 COMPACTION

- A. Compact materials to 100 percent of maximum density as determined from Standard Proctor.

END OF SECTION

SECTION 32 12 16

ASPHALT PAVING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Asphalt materials.
 - 2. Aggregate materials.
 - 3. Aggregate sub-base.
 - 4. Asphalt paving base course, binder course, and wearing course.
 - 5. Asphalt paving overlay for existing paving.
 - 6. Surface slurry.

1.02 REFERENCE STANDARDS

- A. Standard Specifications, Construction of Roads and Bridges, Latest Edition - Department of Transportation, State of Georgia.

1.03 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Product Data:
 - 1. Submit product information for asphalt and aggregate materials.
 - 2. Submit mix design with laboratory test results supporting design.
- C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.04 QUALITY ASSURANCE

- A. Mixing Plant: Conform to Georgia Department of Transportation standards.

1.05 QUALIFICATIONS

- A. Installer: Company specializing in performing work of this section with minimum 3 years documented experience.

1.06 AMBIENT CONDITIONS

- A. Section 01 50 00 - Temporary Facilities and Controls: Ambient conditions control facilities for product storage and installation.

PART 2 PRODUCTS

2.01 ASPHALT PAVING

- A. Performance / Design Criteria:

1. Paving: Design for main street arteries.
- B. Asphalt Materials:
1. Asphalt Cement: ASTM D946; penetration grade 85-100.
 2. Primer: ASTM D2027, MC-70. In accordance with Georgia DOT Standard Specifications.
 3. Tack Coat: ASTM D977; emulsified asphalt.
- C. Aggregate Materials:
1. Coarse Aggregate: ASTM D692; crushed stone, gravel, or blast furnace slag.
 2. Fine Aggregate: ASTM D1073; natural sand or sand manufactured from stone, gravel, or blast furnace slag.
 3. Crushed stone base shall meet the requirements of Georgia DOT Standard Specifications, latest edition
- D. Sub-base Aggregate: ASTM D2940; graded type.

Sieve Size	Percent Passing
2 inches	100
No. 4	30 to 60
No. 200	0 to 12

- E. Base Aggregate: ASTM D2940; graded type.

Sieve Size	Percent Passing
2 inches	100
1-1/2 inches	95 to 100
3/4 inches	70 to 92
3/8 inches	50 to 70
No. 4	35 to 55
No. 30	12 to 25
No. 200	0 to 8

2.02 MIXES

- A. Use dry material to avoid foaming. Mix uniformly.
- B. Asphalt Paving Mixtures: Designed in accordance with Georgia DOT Standard Specifications. Latest edition.

2.03 CONCRETE

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

2.04 PAINT TRAFFIC STRIPING

- A. Section 652, GDOT Standard Specifications, latest edition.

2.05 THERMOPLASTIC TRAFFIC STRIPE

- A. Section 653, GDOT Standard Specifications for Roads and Bridges, latest edition.
- B. Sealing Primer and the proportions used shall be as recommended by the manufacturer of the thermoplastic compound.

2.06 SOURCE QUALITY CONTROL

- A. Section 01 40 00 - Quality Requirements: Testing, inspection and analysis requirements.
- B. Submit proposed mix design of each class of mix for review prior to beginning of Work.

PART 3 EXECUTION

3.01 SURFACE PREPARATION

- A. Sub-base Preparation:
 - 1. The Contractor shall remove from the area all organic substance encountered to a depth of 6-in or 8-in, as shown on the Drawings, below the surface of the proposed subgrade. The entire area shall be plowed and dragged prior to placing a stabilizing additive, if required to meet minimum bearing value.
 - 2. Sub-base shall be compacted to a minimum density of 95 percent of the maximum as determined by the Modified Proctor Density AASHTO T180, and shall have a minimum bearing value of 60 pounds per square inch.
- B. Base Course:
 - 1. Check subgrade for conformity with elevations and section immediately before placing base material.
 - 2. Place base material in compacted layers not more than 6-inches thick, unless continuing tests indicate the required results are being obtained with thicker layers.
 - 3. In no case will more than 8-inches of compacted base be placed in one lift.
 - 4. Spread, shape, and compact all base material deposited on the subgrade during the same day.
 - 5. Compact base course material to not less than 95 percent of maximum density: ASTM D 1557, Method D (98 percent maximum density: AASHTO T-180.)
 - 6. Test density of compacted base course: ASTM D 2167.
 - 7. One test for each 250-sq yd of in-place material shall be conducted, but in no case not less than one daily for each layer.
- C. Loose and Foreign Material:
 - 1. Remove loose and foreign material from compacted sub-base surface immediately before application of paving.
 - 2. Use power brooms or blowers, and hand brooming as required.
 - 3. Do not displace sub-base material.

- D. Prime Coat:
 - 1. Uniformly apply at rate of 0.20 to 0.5 gal/sq yd over compacted and cleaned sub-base surface.
 - 2. Apply enough material to penetrate and seal, but not flood the surface.
 - 3. Allow to cure and dry as long as required to attain penetration and evaporation of volatile, and in no case less than 24 hours unless otherwise acceptable to the Engineer.
 - 4. Blot excess asphalt with just enough sand to prevent pick-up under traffic.
 - 5. Remove loose sand before paving.
- E. Tack Coat:
 - 1. Dilute material with equal parts of water and apply to contact surfaces of previously constructed asphalt concrete or Portland cement concrete and similar surfaces.
 - 2. Apply at rate of 0.05 to 0.15 gal/sq yd of surface.
 - 3. Apply tack coat by brush to contact surfaces of structures projecting into or abutting asphalt concrete pavement.
 - 4. Allow surfaces to dry until material is at condition of tackiness to receive pavement.

3.02 PREPARING THE MIXTURE

- A. Comply with ASTM D 995 for material storage, control, and mixing, and for plant equipment and operation.
- B. Stockpiles:
 - 1. Keep each component of the various-sized combined aggregates in separate stockpiles.
 - 2. Maintain stockpiles so that separate aggregate sizes will not be intermixed and to prevent segregation.
- C. Heating:
 - 1. Heat the asphalt cement at the mixing plant to viscosity at which it can be uniformly distributed throughout mixture.
 - 2. Use lowest possible temperature to suit temperature-viscosity characteristics of asphalt.
 - 3. Do not exceed 350° F.
- D. Aggregate:
 - 1. Heat-dry aggregates to reduce moisture content to not more than 2.0 percent.
 - 2. Deliver dry aggregate to mixer at recommended temperature to suit penetration grade and viscosity characteristics of asphalt cement, ambient temperature, and workability of mixture.
 - 3. Accurately weigh or measure dry aggregates and weigh or meter asphalt cement to comply with job-mix formula requirements.
- E. Mix aggregate and asphalt cement to achieve 90-95 percent of coated particles for base mixtures and 85-90 percent of coated particles for surface mixture, when tested in accordance with ASTM D 2489.
- F. Transporting:
 - 1. Transport asphalt concrete mixtures from mixing site in trucks having tight, clean compartments.
 - 2. Coat hauling compartments with a lime/water mixture to prevent asphalt concrete mixture from sticking.
 - 3. Elevate and drain compartment of excess solution before loading mix.

4. Provide covers over asphalt concrete mixture when transporting to protect from weather and to prevent loss of heat.
5. During periods of cold weather or for long-distance deliveries, provide insulation around entire truck bed surfaces.

3.03 EQUIPMENT

- A. Provide size and quantity of equipment to complete the work specified within project time schedule.
- B. Bituminous Pavers: Self-propelled that spread hot asphalt concrete mixtures without tearing, shoving or gouging surfaces, and control pavement edges to true lines without use of stationary forms.
- C. Rolling Equipment:
 1. Self-propelled, steel-wheeled and pneumatic-tired rollers that can reverse direction without backlash.
 2. Other type rollers may be used if acceptable to the Engineer.
- D. Hand Tools: Provide rakes, lutes, shovels, tampers, smoothing irons, pavement cutters, portable heaters, and other miscellaneous small tools to complete the work specified.

3.04 PLACEMENT

- A. Place asphalt concrete mixture on prepared surface, spread and strike-off using paving machine.
- B. Spread mixture at a minimum temperature of 225 °F.
- C. Inaccessible and small areas may be placed by hand.
- D. Place each course at thickness so that when compacted it will conform to the indicated grade, cross-section, finish thickness, and density indicated.
- E. Paver Placing:
 1. Unless otherwise directed, begin placing along centerline of areas to be paved on crowned section, and at high side of sections on one-way slope, and in direction of traffic flow.
 2. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips.
 3. Complete base course for a section before placing surface courses.
 4. Place mixture in continuous operation as practicable.
- F. Hand Placing:
 1. Spread, tamp, and finish mixture using hand tools in areas where machine spreading is not possible, as acceptable to Engineer.
 2. Place mixture at a rate that will insure handling and compaction before mixture becomes cooler than acceptable working temperature
- G. Joints:

1. Carefully make joints between old and new pavements, or between successive days' work, to ensure a continuous bond between adjoining work.
2. Construct joints to have same texture, density and smoothness as adjacent sections of asphalt concrete course.
3. Clean contact surfaces free of sand, dirt, or other objectionable material and apply tack coat.
4. Offset transverse joints in succeeding courses not less than 24-in.
5. Cut back edge of previously placed course to expose an even, vertical surface for full course thickness.
6. Offset longitudinal joints in succeeding courses not less than 6-in.
7. When the edges of longitudinal joints are irregular, honeycombed, or inadequately compacted, cut back unsatisfactory sections to expose an even, vertical surface for full course thickness.

3.05 COMPACTION

- A. Provide sufficient rollers to obtain the required pavement density.
- B. Begin rolling operations as soon after placing when the mixture will bear weight of roller without excessive displacement.
- C. Do not permit heavy equipment, including rollers to stand on finished surface before it has thoroughly cooled or set.
- D. Compact mixture with hot hand tampers or vibrating plate compactors in areas inaccessible to rollers.
- E. Start rolling longitudinally at extreme lower side of sections and proceed toward center of pavement. Roll to slightly different lengths on alternate roller runs.
- F. Do not roll centers of sections first under any circumstances.
- G. Breakdown Rolling:
 1. Accomplish breakdown or initial rolling immediately following rolling of transverse and longitudinal joints and outside edge.
 2. Operate rollers as close as possible to paver without causing pavement displacement.
 3. Check crown, grade, and smoothness after breakdown rolling.
 4. Repair displaced areas by loosening at once with lutes or rakes and filling, if required, with hot loose material before continuing rolling.
- H. Second Rolling:
 1. Second rolling shall be made by a traffic roller.
 2. Follow breakdown rolling as soon as possible, while mixture is hot and in condition for compaction.
 3. Continue second rolling until mixture has been thoroughly compacted.
- I. Finish Rolling:
 1. Perform finish rolling while mixture is still warm enough for removal of roller marks.
 2. Continue rolling until roller marks are eliminated and course has attained specified density.

- J. Patching:
 - 1. Remove and replace defective areas.
 - 2. Cutout and fill with fresh, hot asphalt concrete.
 - 3. Compact by rolling to specified surface density and smoothness.
 - 4. Remove deficient areas for full depth of course.
 - 5. Cut sides perpendicular and parallel to direction of traffic with edges vertical.
 - 6. Apply tack coat to exposed surfaces before placing new asphalt concrete mixture.

3.06 FRAME ADJUSTMENTS (if applicable)

- A. Placing Frames:
 - 1. Surround frames set to elevation with a ring of compacted asphalt concrete base prior to paving.
 - 2. Place asphalt concrete mixture up to 1-in below top of frame, slope to grade, and compact by hand tamping.
- B. Adjust frames to proper position to meet paving.
- C. If permanent covers are not in place, provide temporary covers over openings until completion of rolling operations.
- D. Set cover frames to grade, flush with surface of adjacent pavement.

3.07 MARKING ASPHALT CONCRETE PAVEMENT

- A. Cleaning:
 - 1. Sweep surface with power broom supplemented by hand brooms to remove loose material and dirt.
 - 2. Do not begin marking asphalt concrete pavement until acceptable to the Engineer.
- B. Apply thermoplastic material as specified by Section 653.03, DOT Std. Specifications.
 - 1. Provide uniform straight edges.
 - 2. Thickness shall be as required by Sec. 653.03.B.1 DOT Std. Specifications.

3.08 CLEANING AND PROTECTION

- A. Cleaning: After completion of paving operations, clean surfaces of excess or spilled asphalt materials to the satisfaction of the Engineer.
- B. Protection:
 - 1. After final rolling, do not permit vehicular traffic on asphalt concrete pavement until it has cooled and hardened, and in no case sooner than 6 hours.
 - 2. Provide barricades and warning devices as required to protect pavement.
 - 3. Cover openings of structures in the area of paving until permanent coverings are placed (if applicable).

3.09 EXISTING PAVING

- A. Where existing paving is shown to be re-paved, the Contractor shall remove and patch any paving damaged due to construction. Patching of damaged paving shall consist of removing all broken asphalt; installing base per the detail shown on the plans or re-compacting if not

damaged; installing the binder course (along with prime coat) to bring the damaged paving up to grade with the existing paving; installing the surface course over the existing paving or repaired section.

3.10 RESURFACING OF EXISTING PAVING

- A. Re-Surfacing of damaged paving shall consist of saw cutting and removing all broken asphalt; installing base per the detail shown on the plans or re-compacting if not damaged; installing the binder course (along with prime coat) to bring the damaged paving up to grade with the existing paving. The re-surfacing of damaged paving shall be paid for per the unit price set up in the bid proposal. Only asphalt that fails due to the loads on the road associated with normal construction activity will be eligible for this pay item. Damage due to running non-road rated equipment over the asphalt will be repaired by the Contractor at his own expense.

3.11 PATCHING OF PAVING

- A. Patching of existing paving where the Contractor must perform work in the road with piping, electrical, or any other construction item shown on the plans will be repaired as described in paragraph 3.10 and will be at the expense of the Contractor.

END OF SECTION

SECTION 32 13 13
CONCRETE PAVING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Aggregate base course.
 - 2. Concrete paving for:
 - a. Concrete sidewalks.
 - b. Concrete stair steps.
 - c. Concrete curbs and gutters.
 - d. Concrete median barriers.
 - e. Concrete parking areas and roads.
- B. Related Requirements:
 - 1. Section 09 90 00 - Painting and Coating: Pavement markings.
 - 2. Section 32 11 23 - Aggregate Base Courses.
 - 3. Section 32 12 16 - Asphalt Paving: Asphalt.

1.02 REFERENCE STANDARDS

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M324 - Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.
- B. American Concrete Institute:
 - 1. ACI 301 - Specifications for Structural Concrete.
 - 2. ACI 304 - Guide for Measuring, Mixing, Transporting, and Placing Concrete.
- C. ASTM International:
 - 1. ASTM A184/A184M - Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement.
 - 2. ASTM A185/A185M - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
 - 3. ASTM A497/A497M - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.
 - 4. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - 5. ASTM A706/A706M - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - 6. ASTM A767/A767M - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
 - 7. ASTM A775/A775M - S Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
 - 8. ASTM A884/A884M - Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement.

9. ASTM A934/A934M - Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars.
10. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
11. ASTM C33 - Standard Specification for Concrete Aggregates.
12. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
13. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
14. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete.
15. ASTM C150 - Standard Specification for Portland Cement.
16. ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete.
17. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
18. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
19. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
20. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
21. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
22. ASTM C595 - Standard Specification for Blended Hydraulic Cements.
23. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
24. ASTM C979 - Standard Specification for Pigments for Integrally Colored Concrete.
25. ASTM C989 - Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.
26. ASTM C1017/C1017M - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
27. ASTM C1064/C1064M - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
28. ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
29. ASTM C1315 - Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
30. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
31. ASTM D1752 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
32. ASTM D6690 - Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

1.03 PRE-INSTALLATION MEETINGS

- A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.04 SUBMITTALS

1. Not Required

1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with Section 03 00 00.
- B. Obtain cementitious materials from same source throughout.
- C. Perform Work in accordance with the State of Georgia Department of Transportation

1.06 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum three years documented experience approved by manufacturer.

1.07 AMBIENT CONDITIONS

- A. Section 01 50 00 - Temporary Procedures and Controls: Ambient conditions control facilities for product storage and installation.
- B. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

PART 2 PRODUCTS

2.01 AGGREGATE SUBBASE

- A. Aggregate Subbase: As specified in Section 32 11 23.

2.02 CONCRETE PAVING

- A. Performance / Design Criteria:
 - 1. Paving: Design for residential streets.
- B. Form Materials:
 - 1. Form Materials: As specified in Section 03 00 00.
- C. Concrete Materials:
 - 1. Concrete Materials: As specified in Section 03 00 00.

2.03 FABRICATION

- A. Fabricate reinforcing in accordance with State of Georgia Department of Transportation.

2.04 MIXES

- A. Concrete Mix - By Performance Criteria: State of Georgia Department of Transportation. Section 430
 - 1. Mix and deliver concrete in accordance with ASTM C94

2.05 ACCESSORIES

- A. Curing Compound: ASTM C309, Type 2, Class A.
- B. Joint Sealers: ASTM D6690; hot applied type.

2.06 SOURCE QUALITY CONTROL

- A. Section 01 40 00 - Quality Requirements: Testing and Inspection Services
- B. Submit proposed mix design of each class of concrete to appointed firm for review prior to commencement of Work.
- C. Tests on cement, aggregates, and mixes will be performed to ensure conformance with specified requirements.
- D. Test samples in accordance with ASTM C94

PART 3 EXECUTION

3.01 EXAMINATION

- A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify compacted subgrade is dry and ready to support paving and imposed loads.
 - 1. Remove soft subbase and replace with compacted fill as specified in Section 31 00 00.
- C. Verify gradients and elevations of base are correct.

3.02 PREPARATION

- A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation preparation.
- B. Moisten substrate to minimize absorption of water from fresh concrete.
- C. Coat surfaces of catch basin frames with oil to prevent bond with concrete paving.
- D. Notify Architect/Engineer minimum 24 hours prior to commencement of concreting operations.

3.03 INSTALLATION

- A. Base Course:
 - 1. Prepare base course in accordance with Public Work's standards.
- B. Forms:
 - 1. Place and secure forms and screeds to correct location, dimension, profile, and gradient.
 - 2. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

3. Not required for roadway trench cap.
- C. Reinforcement:
 1. Place reinforcing as indicated on Drawings.
 2. Interrupt reinforcing at expansion joints.
 3. Place dowels to achieve paving and curb alignment as detailed.
- D. Placing Concrete:
 1. Place concrete in accordance with State of Georgia Department of Transportation specifications.
- E. Joints
 1. Saw cut contraction joints 3/16 inch wide at an optimum time after finishing. Cut 3/4 inch into depth of slab every 5 linear feet.
- F. Finishing:
 1. Roadway Trench Cap Paving: rough finish with exposed aggregate.
 2. Sidewalk Paving: Light broom and trowel joint edges.
 3. Curbs and Gutters: Light broom.
 4. Direction of Texturing: Parallel to paving direction.
 5. Inclined Vehicular Ramps: Broomed perpendicular to slope.
 6. Place curing compound on exposed concrete surfaces immediately after finishing.
- G. Curing and Protection
 1. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.
 2. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
 3. Cure floor surfaces in accordance with ACI 301.

3.04 TOLERANCES

- A. Section 01 40 00 - Quality Requirements: Tolerances.
- B. Maximum Variation of Surface Flatness: 1/2 inch in 10 ft.
- C. Maximum Variation from True Position: 1/2 inch.

3.05 FIELD QUALITY CONTROL

- A. Section 01 40 00 - Quality Requirements: Requirements for inspecting, testing.
- B. Testing firm will take cylinders and perform slump tests in accordance with ACI 301.

3.06 PROTECTION

- A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Immediately after placement, protect paving from premature drying, excessive hot or cold temperatures, and mechanical injury.

- C. Do not permit pedestrian or vehicular traffic over paving for 7 days minimum after finishing.
- D. Repair or restore damaged concrete to the Engineer's satisfaction at no additional cost to the Owner.

END OF SECTION

SECTION 32 16 00

CURBS, GUTTERS, SIDEWALKS AND DRIVEWAYS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Work included in this Section consists of new or replacement of sidewalks, curbs and gutters.

1.02 RELATED WORK

- A. Section 31 00 00 - Earthwork
- B. Section 32 12 16 - Asphalt Pavement
- C. Section 03 30 00 - Cast-in-Place Concrete

1.03 REFERENCES

- A. Standard Specifications, Construction of Roads and Bridges, Latest Edition - Department of Transportation, State of Georgia.

PART 2 PRODUCTS

2.01 CRUSHED STONE BASE

- A. Stone base shall be a graded aggregate conforming to the following:

Sieve Size	% Passing by Weight
2"	100
1½"	97-100
¾"	60-90
No. 10	25-45
No. 60	5-30
No. 200	0-15

2.02 CONCRETE

- A. Shall be ready-mixed concrete no less than 3,000psi at 28 days, GDOT Class "A" as specified under Section 03 30 00 of these Specifications.

PART 3 EXECUTION

3.01 GENERAL

- A. Restore all sidewalks, driveways, curbs and gutters to or better than the original, but not less thickness than specified herein or shown on the Drawings.

- B. Carefully backfill any excavated area on which sidewalks, driveways or curbs and gutters are to be placed as specified in Section 31 00 00 of these Specifications as applicable.
- C. If, prior to the expiration of the warranty period, any sidewalk, driveway or curb and gutter which has been damaged, due to undermining, or for any other cause which may be attributed to the work of the Contractor, the Contractor shall remove such damaged work and all loose earth. He shall then backfill with crushed stone base, properly compacted, and replace damaged concrete.
- D. Work which the Contractor may do in connection with the replacement and repair of damaged work during the period of maintenance, shall be done at his expense, in accordance with the rules and requirements of the authority within whose jurisdiction such pavement is located, and in accordance with the additional requirements of the specifications, and the Contractor shall furnish evidence to the Engineer that the work has been completed to the satisfaction of such authority.
- E. Before replacing any sidewalk, driveway or curb and gutter, remove the existing sidewalk, driveway and/or curb and gutter back from the edge of excavation at least 12 inches or to the nearest joint if the nearest joint is within two (2) feet.
- F. All cuts shall be made by channeling machine, pneumatic tools, or such other methods as will furnish a straight clean cut in the concrete without undue shattering.
- G. Provide crushed stone base over trenches after completion of backfill.
- H. Should settlement, cracks or other indications of failure appear in concrete, the defective concrete shall be removed to the extent necessary to secure firm, undisturbed bearing and shall be re-laid in a satisfactory manner.

3.02 CURBS AND GUTTERS

- A. Portland Cement Concrete curbs and gutters shall conform to Section 441 of Georgia D.O.T. Standard Specifications. Match existing curb. Construct 1/2" wide expansion joints with pre-molded joints filler across curb at all tangent points and at fifty feet intervals and one inch wide expansion joint filler and 3/4" joint sealing between curbs and concrete paving. Finish curb surface with dense uniform texture equal to burlap drag, and cross-score with 1/4" deep cross joints at ten foot intervals.
- B. Concrete curbs and gutters shall be finished in accordance with Section 03 30 00 Cast in Place Concrete. Face forms shall be removed as soon as possible and the exposed surfaces finished with a wood float. Straight edging, done along the edge of the gutter and top of curb and median shall conform to those requirements for the adjacent pavement, but with no irregularities to exceed 1/4 inch in 10 feet. Machine methods of placing may be used, providing the end result is satisfactory.

3.03 SIDEWALKS AND DRIVEWAYS

- A. Shall conform to requirements of Section 441 of Georgia D.O.T. Standard Specifications. Minimum sidewalk thickness shall be 4 inches. Provide transverse contraction joints at 6' interval by cutting a groove in the fresh concrete 1" deep with a jointer having an approved radius and a cutting blade not over 1/8" thick.

- B. Construct 1/2" wide expansion joints with pre-molded joint filler across walks at a maximum of fifty feet intervals. Finish to a broom and burlap drag gritty surface. Tool all joints and all edges to provide smooth border between sections. Match existing sidewalks.
- C. Concrete sidewalks and driveways shall be given a finish made by stiff-bristle brooming. The surface shall be tested with a 10 foot straightedge laid parallel to the centerline. Any irregularities in excess of 1/4 inch in 10 feet shall be eliminated while the concrete is still plastic. Concrete sidewalk constructed as curb cut (wheelchair) ramps shall have a rough or textured finish.

3.04 CLEAN UP

- A. Before work shall be considered complete, remove material not used and rubbish of every character from job site.
- B. Any subsequent settlement of backfill shall be repaired and the surface shall be brought to grade.
- C. Any and all items disturbed by the construction shall in every case be restored to their original condition as closely as possible after completion of the construction.

END OF SECTION

SECTION 32 19 00

GRANULAR SURFACE PAVING

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. WORK included in this section consists of construction of new stone pavement surfaces including subgrade construction and unpaved road shoulder construction.
- B. The contractor shall visit the site and become familiar with the existing conditions.
- C. The work includes construction layout, establishing grade stakes, radii points, construction baselines and all necessary field engineering to control the work in conformance with the plans and specifications. This work will be performed under the direct supervision of an experienced Registered Land Surveyor.

1.02 QUALITY ASSURANCE

- A. All work and materials pertinent to this section of the Specifications are to be in accordance with applicable Sections and Paragraphs of Standard Specifications (hereinafter referred to as Georgia DOT specifications), except for the deviations shown on the plans and/or as specified herein.
- B. Notify Owner if conditions exist that will prevent the work from being performed adequately.

1.03 REFERENCES

- A. Standard Specifications, Construction of Roads and Bridges, Latest Edition - Department of Transportation, State of Georgia, Section 318.

1.04 JOB CONDITIONS

- A. Paving operations shall not begin until all underground work of other trades have been completed and all drainage structures installed in areas which are to be paved.
- B. Verify all grades and elevations shown on drawings before proceeding with work. While grades and elevations will, in general, conform to those shown on drawings, Owner reserves the right to make minor modifications by reasonable field adjustments prior to completion of subgrade work.
- C. Paving shall be done in dry weather when subgrade is sufficiently stable to be properly compacted. Ground moisture shall not be sealed under paving. All work shall be in accordance with applicable sections of the Reference Standards.
- D. CONTRACTOR will provide loaded dump trucks with minimum weight twenty (20) tons load for proof-roll testing when subgrade is ready for inspection or other equipment as recommended by the Soils ENGINEER. OWNER's representative will observe and approve proof-rolling. Provide OWNER with delivery tickets showing actual tons of stone. Tickets must be marked with job name.

PART 2 PRODUCTS

2.01 SUBGRADE SOILS

- A. Unless otherwise noted, the 6" to 12" of subgrade shall be material suitable for providing an acceptable foundation for supporting granular surface courses and traffic.

2.02 COARSE AGGREGATE

- A. Material used for a coarse aggregate surface course shall meet the requirements of the Georgia DOT Standard Specifications, Section 800.01.

2.03 STABILIZER AGGREGATE

- A. Material used for stabilizer aggregate shall meet the requirements of the Georgia DOT Standard Specifications, Section 803.01, Type I Stabilizer or 803.01 Type II as shown on the plans.

2.04 GRADED AGGREGATE BASE COURSE

- A. Material used for a graded aggregate base course shall meet the requirements of the Georgia DOT Standard Specifications, Section 815.01.

2.05 UNPAVED ROAD SHOULDERS

- A. Materials used for unpaved shoulders shall meet the requirements of the Georgia DOT Standard Specifications, Section 817.01.

PART 3 EXECUTION

3.01 INSPECTION

- A. The contractor shall examine all areas made ready for his work, including but not limited to, subgrade compaction, moisture content, drainage, and elevations. Any defects which may adversely affect proper installation of this work shall be reported to the owner in writing and shall have been corrected before the start of this work.

3.02 SUBGRADE

- A. The entire surface of the in-place subgrade shall be plowed, harrowed and mixed to a depth of at least 6". If stabilization stone is required by the ENGINEER, it shall be mixed into the subgrade at this time at the specified rate. After the material has been thoroughly mixed, the subgrade shall be brought to line and grade and compacted to 100% of the maximum laboratory dry density as determined by the Standard Proctor test.
- B. Prior to placing any subsequent layers of aggregate surface course materials, the subgrade shall have sufficient stability to support construction equipment without excessive movement regardless of compaction. Areas of subgrade that are unstable shall be reworked to a moisture content that will provide stability and compaction.

- C. The surface of the completed subgrade shall be bladed to a smooth and uniform texture. The subgrade surface shall conform to the established elevations with an acceptable tolerance of $\pm 1/2$ inch.
- D. The subgrade shall be proof rolled to locate unstable areas and achieve additional compaction.

3.03 CONSTRUCTION

- A. Materials in the Roadbed: The ENGINEER will determine whether the materials in the roadbed are to be used. If it is necessary to remove unsuitable materials, they shall be removed and paid for separately as unclassified excavation. If it is necessary to add other materials to those in the roadbed or to build up the surface course entirely with new materials, the CONTRACTOR shall bring in the approved materials, which will be accepted on a visual basis by the ENGINEER, and construct the surface course as provided for in this Specification. If the materials in place in the roadbed or specified driveway areas are satisfactory for use as shown by tests and approved by the ENGINEER, they shall be mixed, shaped and rolled in accordance with these Specifications.
- B. Preparation of the Roadbed: If this course is to be composed entirely of new materials, the subgrade shall be prepared as specified in Section 3.02 of this specification, or if in-place material is to be used, the surface shall previously have been properly shaped. No select materials shall be placed on a muddy or frozen subgrade.
- C. Placing, Mixing and Rolling: Selected material shall be placed and spread to the prescribed thickness and cross-section. The selected material may be dumped in windrows parallel to the centerline of the roadway or driveway and spread to a uniform thickness by approved methods. After spreading, the selected material shall be scarified and uniformly mixed and shaped to the required cross-section. It shall then be rolled until the surface is thoroughly compacted, firm and unyielding. Water shall be added, if needed, to assist with the scarifying and compaction operations. Sections of the finished roadway, where the original material in place has been approved to be suitable as a selected material surface course, shall be scarified, mixed, shaped, and compacted in accordance with these Specifications for the applicable material. If additional selected material surface course is needed to develop the depth of surfacing shown on the Plans, it shall be added and the surfacing constructed as herein provided. When stabilizer aggregate is specified, it shall be mixed into the surface course in accordance with the provisions of 303.04.D.4. of the referenced specifications. Where aggregate surface course is specified, it shall be the specified aggregate or stabilizer material uniformly spread to the required depth at locations shown on the plans or as directed by the ENGINEER.

3.04 MAINTENANCE

- A. When completed, all areas of Granular Material Surface Course shall be maintained to the required cross-section and kept usable until the project is completed and accepted.

3.05 UNPAVED SHOULDERS

- A. General: All shoulders shall be shaped and compacted in proper sequence for the type of base or pavement being constructed. Any damage that occurs to an existing base, surfacing or pavement due to the operation of constructing shoulders shall be promptly repaired by the CONTRACTOR at his own expense.

- B. Compaction: In order to reduce erosion, compaction of shoulders shall be done as soon as possible.
- C. Maintenance: Shoulders constructed in advance of flexible bases shall have sufficient weep holes cut through them to prevent impoundment of water on the roadbed or subgrade. When front slopes are subject to excessive erosion by concentrated water at weep holes, the contractor shall provide adequate temporary drainage facilities to prevent the erosion. Excessive erosion, when it does occur, shall be promptly repaired by the contractor in order to prevent damage to the adjacent base or pavement. Final shaping, dressing and compaction of shoulders shall also include repairing and dressing adjacent slopes and the removal of excess material from adjacent ditches.

END OF SECTION

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 SCOPE

- A. The work covered in this section shall include all materials, labor, and equipment necessary for a complete installation of the chain link, and cattle fencing as shown on the Contract Drawings.

1.02 RELATED

- A. Section 03 30 00 - Concrete
- B. Section 05 00 00 – Miscellaneous Metals

1.03 REFERENCES - ASTM SPECIFICATIONS

- A. ASTM A 392 Zinc-Coated Steel Chain Link Fence Fabric.
- B. ASTM A 824 Metallic-Coated Marcellled Tension Wire for use with Chain Link Fence Fabric.
- C. ASTM A-121 Standard Specification for Zinc Coated (Galvanized) Steel Barbed Wire.
- D. ASTM F 552 Definitions of Terms Relating to Chain Link Fencing.
- E. ASTM F 567 Standard Practices for Installation of Chain-Link Fence.
- F. ASTM F 626 Standard Specifications for Fence Fittings.
- G. ASTM F 669 Standard Specification for Strength Requirements of Metal Posts and Rails for Industrial Chain Link Fence.
- H. ASTM F 1083 Pipe, Steel, Hot-dipped, Zinc-Coated (Galvanized) Welded, for Fence Structures.
- I. ASTM C 94 Ready Mix Concrete.

PART 2 PRODUCT

2.01 ACCEPTABLE MANUFACTURERS:

- A. Tifco.
- B. American Security Fence Corporation.
- C. Southeastern Wire, P.O. Box 1968, Tampa, Florida 33601.
- D. Cyclone Fence (United States Steel Corporation).

- E. Manufacturer and distributor of complete fencing systems, or approved equivalent.

2.02 POSTS AND FABRIC

- A. Posts and fabric shall be as specified in the following table:

	FENCE HEIGHT			
	6 Feet or Less	6 - 8 Feet	8 - 10 Feet	10 - 12 Feet
Fabric	1½" Mesh 9 Ga.	2" Mesh 9 Ga.	2" Mesh 9 Ga.	2" Mesh 9 Ga.
Corner Post	2½"	3"	3½"	4"
Line Post	1½"	2"	2"	2½"
Gate Post	3"	3½"	4"	6"
Top Rail and Brace	1¼"	1¼"	1½"	1½"

Post sizes should conform to Table 1, ASTM F-1083 (schedule 40 steel pipe). All post and rails shall be hot dipped galvanized per ASTM F-1083.

2.03 TOP RAIL

- A. Top Rail shall be continuous with coupling spaced at intervals not to exceed 20 feet.

2.04 POST TOP

- A. All posts shall be provided with post tops which will fit over the outside of posts to exclude moisture and shall be combination tops with barbed wire supporting arms. Post tops shall be provided with a hole suitable for the through passage of the top rail. Posts without barb arms shall be fitted with a cap.
- B. Barbed wire supporting arms shall be at an angle of 45°, and shall be fitted with clips or other means for securing three lines of barbed wire, the top line approximately 12" horizontally from the fence line and 12" above the top of the fabric and the other lines spaced uniformly between the top line and the top of the fabric.

2.05 POST BRACES

- A. A horizontal, galvanized post brace shall extend to each adjacent line post at mid-height of the fabric for each gate, corner, pull and end post. A diagonal ½" diameter truss rod shall also be provided from the line post to the gate, corner, pull, or end post, with a turnbuckle or other equivalent device for tension adjustment. Two diagonal tension truss rods shall be provided for each fence panel adjacent to a gate, end, corner or pull post.

2.06 STRETCHER BAR

- A. Stretcher bars 1/4" x 3/4" inch in size, with length 1" less than fabric height, shall be provided for stretching and securing the fabric at each gate, end, corner and pull post, one for each gate and end post and two for each corner and pull post.

2.07 WIRE

- A. Wire shall be provided along the bottom edge. It shall be not less than No. 7 gauge coiled spring wire. Galvanized ties or clips shall be provided for attaching tension wires to fabric.
- B. Wire ties shall be 9 ga.
- C. Barbed wire shall be two (2) strand 12 ga with 4 points at 5" o.c. per ASTM A-121.

2.08 GATE

- A. Frame
 - 1. Fabricate gate frames from steel pipe to match fence framework. Assemble gate frames by welding or with special fittings and rivets for rigid connections, that provides security against removal or breakage connections.
 - 2. Extend end members of gate frames 1'-0" above to member and prepare to receive 3 strands of wire. Provide clips for securing wire to extensions.
 - 3. Install diagonal cross-bracing consisting of 3/8" diameter adjustable length truss rods on gates to ensure frame rigidity without sag or twist.
 - 4. Fabricate frames of minimum 1½" (NPS).
- B. Fabric - Provide same fabric as for fence. Install fabric with stretcher bars at vertical edges and at top and bottom edges. Attach stretcher bars to gate frame at not more than 15" o.c.
- C. Gate Hardware: Provide hardware and accessories for each gate, in accordance with the following:
 - 1. Hinges: Size and material to suit gate size, non-lift-off type, offset to permit 180 degree gate opening. Provide 1-1/2 pair of hinges for each leaf.
 - 2. Latch: Forked type or plunger-bar type to permit operation from either side of gate, with padlock eye as integral part of latch. center drop to be provided on double gates.
 - 3. Padlock: Bronze cylinder type lock with three (3) keys is to be provided for each set of gates. Locks are to be keyed per Owner's direction.
 - 4. Keeper: Provide keeper for vehicle gates, which automatically engages gate leaf and holds it in open position until manually released.

2.09 FINISHES

- A. Aluminum coating: ASTM A 428 as per manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Do not begin installation and erection before final grading is completed.
- B. Work shall be performed in a safe and orderly fashion in accordance with Occupational Safety and Health Administration (OSHA) regulations.
- C. Coordinate installation of fence in strict accordance with Contract Documents.

3.02 POST INSTALLATION

- A. Excavation: Drill or hand excavate (using post hole digger) holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.
 - 1. Excavate holes for each post to minimum diameter recommended by fence manufacturer, but not less than 4 times largest cross-section of post.
 - 2. Excavate hole depths 3" lower than post bottom, with bottom of posts set not less than 36" below finish grade surface.
- B. Fence Post Setting
 - 1. Line posts shall be placed equidistant at intervals not to exceed 10 ft. O.C. The intervals to be measured parallel to the grade of proposed fence and in the line of the fence.
 - 2. Line, end, corner and pull posts shall be of sufficient length to allow for installation to a depth as shown on RMA detail GC01.
 - 3. Posts shall be set vertically and plumb and encased in cylindrical concrete footings at least four times the post diameter, with at least a 2" cover on the bottom of the post. Extend the concrete at least 2" above grade and crown to shed water.
 - 4. Posts adjacent to building wall shall be located with 4" maximum space between post and building.

3.03 RAIL INSTALLATION

- A. Top Rail: Connect securely to the posts using boulevard clamps or other suitable means, so that a continuous brace is formed.

3.04 CHAIN LINK FABRIC

- A. Chain link fence fabric shall be installed over the outside face of the fence framework. Fabric shall be tied to line posts and middle rails with 9 gage galvanized wire spaced 12" maximum.

3.05 TENSION WIRES

- A. Install tension wires along bottom of fence before stretching fabric and tie to each post. Fasten fabric to tension wire using 9 gauge, wire ties or galvanized wire hog rings spaced 24" o.c.

3.06 BARBED WIRE

- A. Pull wire taut and install to extension arms and secure to end post or terminal arms in accordance with manufacturer's instructions.

3.07 GATES

- A. Install gates plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate.

3.08 STRETCHER BARS

- A. Thread through or clamp to fabric 4" o.c. and secure to posts with metal bands spaced 15" o.c.

3.09 BRACE ASSEMBLIES

- A. Install braces so posts are plumb when diagonal rod is under proper tension.

3.10 SITE RESTORATION/CLEAN-UP

- A. Remove all construction refuse and restore area to original condition.

END OF SECTION

SECTION 32 92 19

SEEDING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Fertilizing.
 - 2. Seeding.
 - 3. Hydroseeding.
 - 4. Mulching.
 - 5. Maintenance.
- B. Related Sections:
 - 1. Section 31 00 00 - Earthwork.
 - 2. Section 32 92 23 - Sodding.

1.02 REFERENCES

- A. ASTM International:
 - 1. ASTM C602 - Standard Specification for Agricultural Liming Materials.
- B. Manual for Erosion and Sediment Control in Georgia, latest edition prepared by Soil and Water Conservation Commission – Current Edition.

1.03 DEFINITIONS

- A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.04 QUALITY ASSURANCE

- A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.
- B. Perform Work in accordance with Manual for Erosion and Sediment Control in Georgia, latest edition prepared by Soil and Water Conservation Commission.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.
- B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

- C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.06 MAINTENANCE SERVICE

- A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for maintenance service.

PART 2 PRODUCTS

2.01 ACCESSORIES

- A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.
- B. Lime: ASTM C602, Class O agricultural limestone containing a minimum 80 percent calcium carbonate equivalent.
- C. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.
- D. Erosion Fabric: Jute matting, open weave.
- E. Stakes: Softwood lumber, chisel pointed.
- F. String: Inorganic fiber.

2.02 SOURCE QUALITY CONTROL

- A. Section 01 40 00 - Quality Requirements: Testing, inspection and analysis requirements.
- B. Analyze to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value.
- C. Provide recommendation for fertilizer and lime application rates for specified seed mix as result of testing.
- D. Testing is not required when recent tests and certificates are available for imported topsoil. Submit these test results to testing laboratory. Indicate, by test results, information necessary to determine suitability.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify prepared soil base is ready to receive the Work of this section.

3.02 FERTILIZING

- A. Apply lime at application rate of 2000 lbs/ac. Work lime into top 6 inches of soil.
- B. Apply fertilizer at application rate of 1800 lb/ac.
- C. Apply after smooth raking of topsoil and prior to roller compaction.
- D. Do not apply fertilizer at same time or with same machine used to apply seed.
- E. Mix fertilizer thoroughly into upper 2 inches of topsoil.
- F. Lightly water soil to aid dissipation of fertilizer. Irrigate top level of soil uniformly.

3.03 SEEDING

- A. Apply seed at rate indicated on Drawings evenly in two intersecting directions. Rake in lightly.
- B. Do not seed areas in excess of that which can be mulched on same day.
- C. Planting Season: As indicated on Drawings.
- D. Do not sow immediately following rain, when ground is too dry, or when winds are over 12 mph.
- E. Roll seeded area with roller not exceeding 112 lbs/linear foot.
- F. Immediately following seeding and compacting, apply mulch to thickness of 1/8 inches. Maintain clear of shrubs and trees.
- G. Apply water with fine spray immediately after each area has been mulched. Saturate to 4 inches of soil.

3.04 HYDROSEEDING

- A. Apply fertilizer, mulch and seeded slurry with hydraulic seeder at rate of 2000 lb/ac evenly in one pass.
- B. After application, apply water with fine spray immediately after each area has been hydroseeded. Saturate to 4 inches of soil and maintain moisture levels two to four inches.

3.05 SEED PROTECTION

- A. Identify seeded areas with stakes and string around area periphery. Space stakes at 36 inches.
- B. Cover seeded slopes where grade is 4 inches per foot or greater with erosion fabric. Roll fabric onto slopes without stretching or pulling.
- C. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12 inches. Backfill trench and rake smooth, level with adjacent soil.

- D. Secure outside edges and overlaps at 36 inch intervals with stakes.
- E. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
- F. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.06 MAINTENANCE

- A. Mow grass at regular intervals to maintain at maximum height of 2-1/2 inches. Do not cut more than 1/3 of grass blade at each mowing. Perform first mowing when seedlings are 40 percent higher than desired height.
- B. Neatly trim edges and hand clip where necessary.
- C. Immediately remove clippings after mowing and trimming. Do not let clippings lay in clumps.
- D. Water to prevent grass and soil from drying out.
- E. Roll surface to remove minor depressions or irregularities.
- F. Control growth of weeds. Apply herbicides. Remedy damage resulting from improper use of herbicides.
- G. Immediately reseed areas showing bare spots.
- H. Repair washouts or gullies.
- I. Protect seeded areas with warning signs during maintenance period.

3.07 SCHEDULE

- A. Area: As indicated on Drawings.

END OF SECTION

SECTION 32 92 23

SODDING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Preparation of subsoil.
 - 2. Placing topsoil.
 - 3. Fertilizing.
 - 4. Sod installation.
 - 5. Maintenance.
- B. Related Sections:
 - 1. Section 31 00 00 - Earthwork.
 - 2. Section 32 92 19 - Seeding and Soil Supplements.

1.02 REFERENCES

- A. ASTM International:
 - 1. ASTM C602 - Standard Specification for Agricultural Liming Materials.
- B. Turfgrass Producers International:
 - 1. TPI - Guideline Specifications to Turfgrass Sodding.

1.03 QUALITY ASSURANCE

- A. Sod: Root development capable of supporting its own weight without tearing, when suspended vertically by holding upper two corners.
- B. Perform Work in accordance with Manual for Erosion and Sediment Control in Georgia, latest edition, prepared by the Georgia Soil and Water Conservation Commission.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.
- B. Deliver sod on pallets. Protect exposed roots from dehydration.
- C. Do not deliver more sod than can be laid within 24 hours.

1.05 MAINTENANCE SERVICE

- A. Section 01 70 00 - Execution and Closeout Requirements: Maintenance service.
- B. Maintain sodded areas sodded areas for three months from Date of Substantial Completion.

PART 2 PRODUCTS

2.01 SOD

- A. Sod: Minimum age of 18 months with root development that will support its own weight without tearing when suspended vertically by holding the upper two corners.

2.02 SOIL MATERIALS

- A. Topsoil: Excavated from site and free of weeds.

2.03 ACCESSORIES

- A. Fertilizer: Commercial grade; recommended for grass, with fifty percent of elements derived from organic sources; of proportion necessary to eliminate deficiencies of topsoil [to the following proportions: nitrogen 5 percent, phosphoric acid 10 percent, soluble potash 10 percent.
- B. Lime: ASTM C602, Class T agricultural limestone containing a minimum 80 percent calcium carbonate equivalent.
- C. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.
- D. Wood Pegs: Softwood, sufficient size and length to anchor sod on slope.
- E. Wire Mesh: Interwoven hexagonal metal wire mesh of 2 inch size.
- F. Edging: Galvanized steel.

2.04 HARVESTING SOD

- A. Machine cut sod [and load on pallets] in accordance with TPI.
- B. Cut sod in area not exceeding 1 sq yd, with minimum 1/2 inch and maximum 1 inch topsoil base.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify prepared soil base is ready to receive the Work of this section.

3.02 PREPARATION OF SUBSOIL

- A. Prepare sub-soil and eliminate uneven areas and low spots.

- B. Maintain lines, levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas.
- C. Remove foreign materials and undesirable plants and their roots. Do not bury foreign material beneath areas to be sodded.
- D. Remove contaminated subsoil.
- E. Scarify sub-soil to depth of 4 inches where topsoil is to be placed.
- F. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.

3.03 PLACING TOPSOIL

- A. Spread topsoil to minimum depth of 3 inches over area to be sodded.
- B. Place topsoil during dry weather and on dry unfrozen subgrade.
- C. Remove vegetable matter and foreign non-organic material from topsoil while spreading.
- D. Grade topsoil to eliminate rough, low or soft areas and to ensure positive drainage.
- E. Install edging at periphery of sodded areas in straight lines to consistent depth.

3.04 FERTILIZING

- A. Apply lime at application rate of 2000lb/ac. Work lime into top 6 inches of soil.
- B. Apply fertilizer at application rate of 1800 lb/ac.
- C. Apply fertilizer after smooth raking of topsoil and prior to installation of sod.
- D. Apply fertilizer no more than 48 hours before laying sod.
- E. Mix fertilizer thoroughly into upper 4 inches of topsoil.
- F. Lightly water soil to aid dissipation of fertilizer.

3.05 LAYING SOD

- A. Moisten prepared surface immediately prior to laying sod.
- B. Lay sod within 24 hours after harvesting to prevent deterioration.
- C. Lay sod tight with no open joints visible, and no overlapping; stagger end joints 12 inches minimum. Do not stretch or overlap sod pieces.
- D. Lay smooth. Align with adjoining grass areas.
- E. Place top elevation of sod 1/2 inch below adjoining edging.

- F. On slopes 6 inches per foot and steeper, lay sod perpendicular to slope and secure every row with wooden pegs at maximum 2 feet on center. When using "big roll", lay sod parallel to slope. Drive pegs flush with soil portion of sod.
- G. Do not place sod when temperature is lower than 32 degrees F.
- H. After sod and soil have dried, roll sodded areas to bond sod to soil and to remove minor depressions and irregularities. Roll sodded areas with roller not exceeding 250 lbs.
- I. Roll before first watering.

3.06 MAINTENANCE

- A. Mow grass at regular intervals to maintain at maximum height of 2-1/2 inches. Do not cut more than 1/3 of grass blade at each mowing.
- B. Neatly trim edges and hand clip where necessary.
- C. Immediately remove clippings after mowing and trimming.
- D. Water to prevent grass and soil from drying out.
- E. Roll surface to remove irregularities.
- F. Control growth of weeds. Apply herbicides. Remedy damage resulting from improper use of herbicides.
- G. Immediately replace sod on areas showing deterioration or bare spots.
- H. Protect sodded areas with warning signs during maintenance period.

END OF SECTION

SECTION 33 01 32

SEWER AND MANHOLE TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Testing Manholes:
 - a. Vacuum Test.
 - 2. Testing Gravity Sewer Piping:
 - a. Low-pressure Air Leakage Test.
 - b. Deflection Testing Plastic Piping.
 - c. Infiltration Test.
 - d. Chemical Grouting.
 - 3. Testing DIP, PVC, and PVCO Forcemain Pressure Piping:
 - a. Hydrostatic Pressure and Leakage Tests.
 - 4. Testing HDPE Pressure Piping
 - a. Hydrostatic Leakage Test
- B. Related Sections:
 - 1. Division 40 – Piping.

1.02 REFERENCES

- A. AWWA: C600, C605, C901, C906, C909
- B. ASTM: C1244, D2122, F2164

1.03 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Submit the following prior to start of testing:
 - 1. Testing procedures.
 - 2. List of test equipment.
 - 3. Testing sequence schedule.
 - 4. Provisions for disposal of flushing and test water.
 - 5. Certification of test gauge calibration.
 - 6. Deflection mandrel drawings and calculations.
- C. Test Reports: Indicate results of manhole and piping tests.

PART 2 PRODUCTS

2.01 GENERAL

- A. List presented below is a partial list and other equipment may be required. CONTRACTOR shall furnish all equipment and personnel required for performing tests.

2.02 EQUIPMENT

A. VACUUM TESTING EQUIPMENT

1. Vacuum pump.
2. Vacuum line.
3. Vacuum tester base with compression band seal and outlet port.
4. Shut-off valve.
5. Stop watch.
6. Plugs.
7. Vacuum gauge, calibrated to 0.1 inch Hg

B. AIR TEST EQUIPMENT

1. Air compressor.
2. Air supply line.
3. Shut-off valves.
4. Pressure regulator.
5. Pressure relief valve.
6. Stop watch.
7. Plugs.
8. Pressure gauge, calibrated to 0.1 psi.

C. INFILTRATION TEST EQUIPMENT

1. Weirs.

D. HYDROSTATIC TEST EQUIPMENT

1. Hydro pump.
2. Pressure hose.
3. Water meter.
4. Test connections.
5. Pressure relief valve.
6. Pressure gauge, calibrated to 0.1 psi.

E. DEFLECTION TEST EQUIPMENT

1. Go, No-Go mandrels.
2. Pull/retrieval ropes.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify manholes and piping are ready for testing.
- C. Verify pressure piping concrete reaction support blocking or mechanical restraint system is installed.

3.02 PIPING PREPARATION

- A. Lamping:
 - 1. Lamp gravity piping after flushing and cleaning.
 - 2. Perform lamping operation by shining light at one end of each pipe section between manholes; observe light at other end; reject pipe not installed with uniform line and grade; remove and reinstall rejected pipe sections; re-clean and lamp until pipe section achieves uniform line and grade.
- B. Plug outlets, wye-branches and laterals; brace plugs to resist test pressures.

3.03 TESTING GRAVITY SEWER PIPING: LOW-PRESSURE AIR LEAKAGE TEST

- A. During the progress of the Work, Contractor shall test, in presence of Owner's Representative, the entire sewer and appurtenances installed for leakage by low pressure air in accordance with ASTM F-1417 or Unibell UNI-B-6.
- B. Contractor will furnish all facilities and personnel for conducting test.
- C. Contractor may desire to make an air test prior to backfilling for his own purposes. However, acceptable air test shall be performed after backfilling and compaction has been completed.
- D. All service laterals shall be plugged with flexible joint caps, or acceptable alternate, securely fastened to withstand the internal test pressures. Such plugs or caps shall be readily removable, and their removal shall provide a socket suitable for making a flexible jointed lateral connection or extension.
- E. Prior to testing for acceptance, pipe should be cleaned by passing through the pipe a full gauge squeegee. It shall be the responsibility of the Contractor to clean pipe before beginning leakage test.
- F. Immediately following pipe cleaning, pipe installation shall be tested with low pressure air.
- G. Test Procedure:
 - 1. During the progress of the Work, Contractor shall test, in presence of Owner's Representative, the entire sewer and appurtenances installed for leakage by low pressure air in accordance with ASTM F-1417 or Unibell UNI-B-6.
 - 2. Contractor will furnish all facilities and personnel for conducting test.
 - 3. Contractor may desire to make an air test prior to backfilling for his own purposes. However, acceptable air test shall be performed after backfilling and compaction has been completed.
 - 4. All service laterals shall be plugged with flexible joint caps, or acceptable alternate, securely fastened to withstand the internal test pressures. Such plugs or caps shall be readily removable, and their removal shall provide a socket suitable for making a flexible jointed lateral connection or extension.
 - 5. Prior to testing for acceptance, pipe should be cleaned by passing through the pipe a full gauge squeegee. It shall be the responsibility of the Contractor to clean pipe before beginning leakage test.
 - 6. Immediately following pipe cleaning, pipe installation shall be tested with low pressure air.

- a. The ends of the pipe section to be tested shall be plugged and air shall slowly fill the pipe until internal air pressure reaches 4.0 pounds per square inch greater than average back pressure of ground water submerging pipe.
 - b. At least two (2) minutes shall be allowed for temperature stabilization before proceeding further.
7. Pipe line shall be considered acceptable when tested at an average pressure of 3.0 pounds per square inch greater than average back pressure of any ground water that may submerge pipe for duration of the test times shown below:

Nominal Pipe Size, inches	Minimum Test Time, minutes	Maximum Length for Minimum Time (ft)	Minimum Time for Longer Length (sec) L=Total Length
4	3:46	597	0.380 L
6	5:40	398	0.854 L
8	7:34	298	1.520 L
10	9:26	239	2.374 L
12	11:20	199	3.218 L
15	14:10	159	5.342 L
18	17:00	133	7.692 L
20/21	19:50	114	10.470 L

Requirements of this specification shall be considered satisfied if time required in seconds for pressure to decrease from 3.5 to 2.5 pounds per square inch greater than average back pressure of ground water that may submerge pipe is not less than that computed according to preceding table.

8. If pipe installation fails to meet these requirements, CONTRACTOR shall determine at his own expense, source or sources of leakage, and shall repair (if extent and type of repairs proposed by CONTRACTOR is approved by ENGINEER), or replace all defective materials or workmanship.
9. Maximum length of section of sewer line to be tested will not exceed 400 feet.
10. Final acceptance of each section or run of sewer tested will not be issued until leakage has been reduced to rates not exceeding maximum specified herein.

H. Safety Precautions:

1. Low pressure air test may be dangerous to personnel if, through lack of understanding or carelessness, a line is over-pressurized or plugs are installed improperly. It is extremely important that various plugs be installed so as to prevent sudden expulsion of a poorly installed or partially inflated plug. Observe the following precautions:
 - a. No one shall be allowed in manholes during testing because of hazards.
 - b. Install all plugs securely.
 - c. When lines are to be tested, it may be necessary that plugs be braced as an added safety factor.
 - d. Do not over pressurize the lines.

- I. Final acceptance of each section or run of sewer tested will not be issued until leakage has been reduced to rates not exceeding maximum specified herein.

- J. The required measurements for leakage shall be made by the Engineer, but the Contractor shall furnish all labor, materials, and equipment; including hose, weirs, and water supply, as may be necessary in making test.
 - 1. No direct or separate payment shall be made for these tests but the cost thereof shall be included in the Unit Prices Bid for pipe installation.

3.04 TESTING GRAVITY SEWER PIPING: DEFLECTION TESTING OF PLASTIC SEWER PIPE

- A. Perform vertical ring deflection testing on PVC sewer piping, after backfilling has been in place for at least 30 days but not longer than 12 months.
- B. Allowable maximum deflection for installed plastic sewer pipe limited to 5% of original vertical internal diameter.
- C. Perform deflection testing using properly sized rigid ball or 'Go, No-Go' mandrel.
- D. Furnish rigid ball or mandrel with diameter not less than 95 percent of base or average inside diameter of pipe as determined by ASTM standard to which pipe is manufactured. Measure pipe in compliance with ASTM D2122.
- E. Perform test without mechanical pulling devices.
- F. Locate, excavate, replace and retest pipe exceeding allowable deflection.

3.05 TESTING GRAVITY SEWER PIPING: INFILTRATION TESTING

- A. Use only when gravity piping has a visible flow of ground water. On newly installed sewers 16 inches or less in diameter, no infiltration or leaks shall be allowed. Any infiltration flowing at the low point of a project must be eliminated prior to approval.
- B. Maximum Allowable Infiltration: 25 gallons per inch of pipe diameter for each mile per day for section under test, include allowances for leakage from manholes. Visible or known leaks shall not be allowed regardless of total infiltration.
- C. Dig up and repair visible or audible leaks, unless the leak is found to be in a joint and can be repaired by chemical grouting.
- D. Test in accordance with ASTM C1091 (Infiltration testing) or ASTM C969.

3.06 TESTING GRAVITY SEWER PIPING: CHEMICAL GROUTING

- A. Should visible leaks of joints be discovered as a result of testing or inspection, chemical grouting will be considered an acceptable remedy only if the Contractor gives an extended warranty period for leakage of five (5) years and posts a maintenance bond to cover any leakage repairs over that time period.
 - 1. Method employed to seal joints in sewers with grout shall require positioning of double-header packer at joint with heads of packer located on both sides of joint to be sealed.
 - 2. When positioned, packer heads will be expanded to provide an effective seal against loss of chemical grout into pipe interior.
 - 3. Grout shall then be introduced into packer under sufficient pressure to force entry through joint into earth surrounding pipe.

- B. Chemical sealing materials shall be two or three part sealant depending upon manufacturer's formula.
 - 1. Basic components shall be base and catalyst which when mixed together under controlled conditions will form a translucent and non-absorptive gel.
 - 2. Gel shall be insoluble in water, kerosene, or gasoline, and shall be resistant to attack by fungi, dilute acids, alkalis, salts and gases found in ground.
 - 3. Final reaction shall produce a continuous cross-linking and irreversible gel.
 - 4. Chemical sealant shall contain approximately 10% of base sealant constituent.
- C. Joints sealed with chemical grout shall be air tested.
 - 1. Method employed to air test joints shall require positioning of double-header packer at joint with heads of packer located on both sides of joint to be tested.
 - 2. When positioned, packer heads will be expanded to provide an effective seal against loss of air into pipe interior.
 - 3. Air shall then be introduced into a packer until a pressure of 4 pounds developed.
 - 4. If this pressure holds for 30 seconds, after air supply is shut off, joint shall be considered acceptable.
 - 5. Should loss of pressure occur during the 30 seconds, joint shall be scheduled for chemical grouting to eliminate leak and this section of pipe shall be re-tested with air per Paragraphs 3a-3c.

3.07 TESTING FORCEMAIN PIPING FOR DIP, PVC AND PVCO: HYDROSTATIC PRESSURE TEST AND LEAKAGE TEST

- A. Perform Hydrostatic pressure test and Leakage test concurrently.
- B. When the force main of an adequate length deemed by Engineer for testing has been installed, including valved section, main shall be filled with clean water, thoroughly blown free of air and prepared for testing.
- C. If directed by Engineer, force main shall be tested before trench is completely backfilled.
- D. Perform tests in the presence of the Engineer.
- E. Perform pressure test for forcemains in accordance with AWWA C600 (DIP) or AWWA C605 (PVC) or AWWA C909 (PVCO) and the following.
 - 1. Furnish and install corporation stops at high points on line to release air as line is filled with water.
 - 2. Furnish gauges, meters, pressure pumps, connections, and other equipment necessary to fill the line slowly, perform the required testing, and accurately measure water introduced into line during testing.
 - 3. Hydrostatically test each portion of pressure piping, including valved section, at 1.5 times working pressure of piping based on elevation of lowest point in piping corrected to elevation of test gauge or 160 psi, whichever is greater.
 - 4. Maintain pressure within plus or minus 5.0 psig of test pressure for a minimum of 2 hours.
 - 5. Locate, remove and replace any defective pipe, valves and fittings. Re-test.
 - 6. Leakage is defined as the quantity of water supplied to piping necessary to maintain test pressure during period of test.
 - 7. Compute maximum allowable leakage by the following formula:

- a. When pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.

$L = (S \cdot D \cdot \sqrt{P}) / 148,000$
L = testing allowance, in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of pipe, in inches
P = average test pressure during hydrostatic test, in psig

- F. Lines which fail to meet tests shall be repaired and re-tested as necessary until test requirements are complied with.

3.08 TESTING FORCEMAIN PIPING FOR HDPE: HYDROSTATIC LEAKAGE TEST

A. Pneumatic testing is prohibited.

- B. The total test time including initial pressurization, initial expansion, and time at test pressure, must not exceed 8 hours.
- C. If the pressure test is not completed due to leakage, equipment failure, etc., the test section shall be de-pressurized, and allowed to “relax” for at least 8 hours before bringing the test section up to test pressure again.
- D. When the force main of an adequate length deemed by Engineer for testing has been installed, including valved section, main shall be filled with clean water, thoroughly blown free of air and prepared for testing.
- E. If directed by the Engineer, force main shall be tested before trench is completely backfilled.
- F. Perform tests in the presence of the Engineer.
- G. Perform test for forcemains in accordance with AWWA C600 (DIP) or AWWA C901/C906 (HDPE) and ASTM F2164 (HDPE) and the following.
 1. Furnish and install corporation stops at high points on line to release air as line is filled with water.
 2. Furnish gauges, meters, pressure pumps, connections, and other equipment necessary to fill the line slowly, perform the required testing, and accurately measure water introduced into line during testing.
 3. Hydrostatically test each portion of pressure piping, including valved section, at 1.5 times working pressure of piping based on elevation of lowest point in piping corrected to elevation of test gauge or 160 psi, whichever is greater.
 4. Initial Expansion Phase:
 - a. During the initial expansion phase, polyethylene pipe will expand slightly, and additional test water will be required. It is not necessary to monitor the amount of water added during the initial expansion phase.
 - b. Gradually pressurize the test section to test pressure and add additional test water as required to maintain test pressure for four (4) hours.
 - c. After 4 hours, the initial expansion should be complete and the actual test can start.
 5. Test Phase:

- a. Immediately following the initial expansion phase, reduce test pressure by 10 psi, and stop adding test liquid. This is the target test pressure.
 - b. If target test pressure remains steady (within 5% of the target value) for one (1) hour, no leakage is indicated.
6. Because joints of HDPE pipe are fused together, the amount of leakage should be zero.
7. For HDPE test sections that also include DIP, PVC or PVCO pipe material, the maximum allowable leakage shall be computed by the following formula:
 - a. When pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.

$L = (S \cdot D \cdot \sqrt{P}) / 148,000$
L = testing allowance, in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of pipe, in inches
P = average test pressure during hydrostatic test, in psig

- H. Lines which fail to meet tests shall be depressurized, all visible leaks repaired and the test section allowed to “relax” (remain depressurized) for at least eight (8) hours before re-testing.

3.09 TESTING MANHOLES: GENERAL

- A. Test using air whenever possible prior to backfilling to assist in locating leaks.
- B. Make joint repairs on both outside and inside of joint to ensure permanent seal. Test manholes with manhole frame set in place.
- C. Make all manholes as near watertight as practicable. Eliminate all visible points of ground water infiltration and any other significant points of leakage which can be located regardless of test results obtained as hereinafter required.
- D. Upon completion of manhole installation and prior to acceptance and payment for completed work, perform manhole vacuum acceptance test for each newly installed precast concrete manhole.

3.10 TESTING MANHOLES: VACUUM TEST

- A. Where adjustment to grade using bricks and mortar is required, test manholes prior to placement of final elevation adjustment and castings.
- B. Vacuum test in accordance with ASTM C1244 and as follows:
 1. Plug all lift holes with a non-shrink grout.
 2. Temporarily plug all pipes entering the manhole and securely brace each plug to prevent them from being pulled into the manhole.
 3. Place the vacuum testing equipment test head at the top of the manhole in accordance with the testing equipment manufacturer’s recommendations.
 4. Draw a vacuum of 10 inches of mercury on the manhole and close the valve on the vacuum line of the testing equipment and shut off the vacuum pump.
 5. Measure the time for the vacuum to drop to 9 inches of mercury.
 6. The manhole shall pass if the time for the vacuum reading to drop from 10 inches of mercury to 9 inches of mercury meets or exceeds the values indicated in the following table:

<u>Depth</u>	<u>Time (Seconds)</u>	
	<u>48" Diameter Manhole</u>	<u>60" Diameter Manhole</u>
0' - 8'	20	26
8' - 10'	25	33
10' - 12'	30	39
12' - 14'	35	46
14' - 16'	40	52
16' - 18'	45	59
18' - 20'	50	65
20' - 30'	80	105

- a. Record vacuum drop during test period; when vacuum drop is greater than 1 inch of Hg during test period, repair and retest manhole; when vacuum drop of 1 inch of Hg does not occur during test period, discontinue test and accept manhole.
- b. When vacuum test fails to meet 1 inch Hg drop in specified time after repair, repair and retest manhole.

END OF SECTION

SECTION 33 05 13

MANHOLES AND STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes: Materials, accessories, equipment, tools, and labor required to install pre-cast concrete manholes; frames and covers; access hatches; manhole rungs; ladders; outside drop manholes; precast concrete structures including vaults, air release valve manholes, valve manholes; concrete meter boxes; vent pipes; and appurtenances as indicated on Drawings and specified in this Section.
- B. Related Sections:
 - 1. Section 01 20 00 – Price and Payment Procedures: Unit Price Schedule.
 - 2. Section 03 10 00 - Concrete Forming and Accessories.
 - 3. Section 03 20 00 - Concrete Reinforcing.
 - 4. Section 03 30 00 - Cast-In-Place Concrete.
 - 5. Section 31 00 00 - Earthwork.
 - 6. Section 33 01 32 - Sewer and Manhole Testing.
 - 7. Section 33 31 10 - Sanitary Utility Sewerage Piping.
 - 8. Section 33 34 00 – Sanitary Utility Sewerage Force mains.

1.02 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Section 01 20 00 - Price and Payment Procedures: Unit Price Schedule.

1.03 REFERENCES

- A. American Association of State Highway Transportation Officials.
- B. American Concrete Institute.
- C. ASTM International.

1.04 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Shop Drawings: Indicate structure locations, elevations, sections, equipment support, piping sizes and elevations of penetrations.
- C. Product Data: Submit manhole covers, component construction, features, configuration, dimensions.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- E. Project Record Documents: Record actual locations of manholes and structures with rim and invert elevations.

- F. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.05 QUALITY ASSURANCE

- A. Obtain precast concrete utility structures from single source.
- B. Perform Work in accordance with Georgia Department of Transportation Standard Specifications.
- C. Maintain one copy of each document on site.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.
- B. Comply with precast concrete manufacturer's instructions and ASTM C913 for unloading, storing and moving precast manholes and drainage structures.
- C. Store precast concrete manholes and drainage structures to prevent damage to Owner's property or other public or private property. Repair property damaged from materials storage.
- D. Mark each precast structure by indentation or waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers shown on Drawings to indicate its intended use.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Masonry Work: Maintain materials and surrounding air temperature to minimum 50 degrees F prior to, during, and 48 hours after completion of masonry work.
- B. Cold Weather Requirements: ACI 530/530.1.

PART 2 PRODUCTS

2.01 CONCRETE

- A. Concrete, cement, sand and water used in manhole construction shall conform to the applicable requirements stated in Section 03 30 00 of these Specifications. All concrete shall be of class shown on Drawings.
- B. Steel reinforcement shall conform to the applicable requirements of Section 03 20 00 of these Specifications.
- C. Grout: Specified in Section 03 30 00.

2.02 PRECAST CONCRETE MANHOLES

- A. Pre-cast concrete manholes shall consist of pre-cast reinforced concrete base sections, riser sections, transition top sections, conical or flat slab top sections, grade rings, conforming with the typical manhole details as shown on Drawings and meeting the following requirements.

- B. Pre-cast manhole sections shall be manufactured, tested, and marked in accordance with latest provisions of ASTM C-478.
- C. Maximum allowable absorption of concrete shall not exceed 8 percent of dry weight.
- D. Circumferential reinforcement in riser sections, conical top sections, and base wall sections shall consist of one line of steel and shall be not less than 0.17 square inch per lineal foot.
- E. Ends of each reinforced concrete manhole riser section and bottom end of manhole top section shall be so formed that when manhole risers and top are assembled, they will make a continuous and uniform manhole.
- F. Joints of manhole sections shall be of tongue and groove type. Sections shall be joined using O-ring rubber gaskets, Kent Seal or Ram-Nek butyl rubber sealer conforming to applicable provisions of ASTM C-443, latest revision, or filled with an approved plastic gasket meeting requirements of Fed. Specifications SS-S-00210, "Sealing Compound, Preformed Plastic for Pipe Joints", Type 1, Rope Form.
- G. Each section of the pre-cast manhole shall have not more than two holes for the purpose of handling and laying. These holes shall be tapered and shall be plugged with rubber stoppers or grout after installation.
- H. Holes in pre-cast bases to receive sewer pipes shall be provided with flexible manhole boots of high quality synthetic rubber.
- I. Holes in manhole bases to receive sewer pipes shall be pre-cast at the factory at required locations and heights. Knocking out of holes in the field will not be permitted.
- J. Manhole inverts shall be constructed in accordance with details on Drawings and shall have the same cross section as the invert of the sewer with which they connect. Invert shall be carefully formed to required size and grade by gradual and even changes in sections. Changes in direction of flow through sewer shall be made to a curve with as large a radius as size of manhole will permit.
- K. **Precast inverts will not be allowed.**

2.03 FRAMES AND COVERS

- A. Manhole frames, steps and covers shall be cast iron conforming to minimum requirements of latest ASTM A-48, for Class 35B Gray Iron Castings. Castings shall be made accurately to required dimensions, fully interchangeable, sound, smooth, clean and free from blisters or other defects. Defective castings which have been plugged or otherwise treated shall not be used. Each casting shall have its actual weight in pounds stenciled or painted on it in white paint.
- B. Manhole frames and covers shall be of size and type as shown on Drawings.
- C. Frames and covers shall be:
 - 1. Equal to Neenah Foundry Co., No. R-1642 with a self-sealing water-tight application.
 - 2. Vented lid: where called for on Drawings, frames and covers shall be equal to Neenah Foundry Co., No. R-1642 with 2 open pick holes.

3. Bolted Water-tight: where called for on Drawings for vented cover, frames and covers shall be equal to Neenah Foundry Co., No.R1916-F.
- D. The covers and frames are to be set flush with finished paving or 6-inches above grade in landscaped areas, unless otherwise specified.
- E. Covers:
 1. Watertight manhole covers, where indicated on Drawings, shall be equal to Neenah Foundry Co., No. R-1916-F (bolt down). All bolts or screws must be stainless steel.
 2. Vented manhole covers, where indicated on Drawings, shall be equal to Neenah Foundry
 3. Contact surfaces of all manhole covers and corresponding supporting rings in rims shall be machined to provide full perimeter contact.
 4. Sanitary sewer manhole covers shall have cast on the top in letters 2 inches high, "Sanitary Sewer". Cover shall be Neenah Type "A".
- F. The installation and attachment of all vault hatchways shall be detailed on a shop drawing and submitted for approval. A steel insert frame shall be cast with the vault and the hatchway bolted to it, either pre- or post-casting.

2.04 BRICK MASONRY

- A. Brick used in manhole construction shall be solid or cored, medium hard or better, Grade SM brick conforming to requirements of ASTM C-32 for sewer and manhole brick.

2.05 MORTAR

- A. Mortar for brick manhole construction shall be sand-cement mortar composed of one part Portland cement to two parts clean sand conforming to ASTM C-144. Twenty pounds of hydrated lime per sack of cement may be added. No re-tempered mortar shall be used.

2.06 OUTSIDE DROP MANHOLES

- A. All drop manholes with outside bowls drop connection shall be provided at all locations as may be directed by the Engineer or indicated on the Contract Drawings. Section shall include all exterior drop pipe additions to standard manholes complete with drop pipe encasement, excavation, and foundation cushion.

2.07 RUNGS FOR MANHOLES AND STRUCTURES

- A. Rungs shall be either of the following types:
 1. Cast aluminum alloy 6061-T6, drop-front design, 12 inches wide, with an abrasive step surface conforming to OSHA requirements.
 2. Steel reinforced, copolymer polypropylene, 14 inches wide, M.A. Industries Inc., PF Series or equal. Copolymer polypropylene shall conform to ASTM D4101 Classification PP2200 B33450 Z02. Steel reinforcing shall be 2-inch diameter, conforming to ASTM A615, Grade 60, and shall be continuous throughout rung.

2.08 PIPE CONNECTIONS TO MANHOLES AND STRUCTURES

- A. Connect pipe to manholes and structures in the following ways:
 - 1. Grout in Place – Precast manhole and vault sections shall have a formed, tapered, circular opening larger than the pipe outside diameter. Grout shall be non-shrink and waterproof equal to Hallemite, Waterplug, or Embecco.
 - 2. Flexible sleeve - Integrally cast sleeve in precast section or install sleeve in a formed or cored opening. Fasten pipe in sleeve with stainless steel clamps. Coat stainless steel clamps with bituminous material to protect from corrosion. Flexible sleeve shall be Lock Joint Flexible Manhole Sleeve; Kor-N-Seal connector type as manufactured by National Pollution Control Systems, Inc ; PSX Press-Seal Gasket or cast-in place type as manufactured by Interpace Division of Ball Rubber, Inc. or approved equal
 - 3. Compression gasket - Integrally cast compression gasket in precast section. Insert pipe into compression gasket. Compression gasket shall be A-Lok, or approved equal.

2.09 BEDDING AND COVER MATERIALS

- A. Bedding: as specified in Section 31 00 00.
- B. Cover: as specified in Section 31 00 00.
- C. Soil Backfill from Above Pipe to Finish Grade: Soil Type As specified in Section 31 00 00.

2.10 DAMPPROOFING

- A. Dampproofing shall be Hydrocide 648 by Sonneborn Building Products; Dehydratine 4 by A.C. Horn Inc.; RIW Marine Liquid by Tock Brothers, or approved equal.

2.11 VAULTS

- A. Vaults are precast concrete structures, square or rectangular in shape, usually with a precast structural invert and top slab. Unless otherwise detailed on Drawings or Specified, they shall have a minimum 6-foot, 6-inch inside height; a 3-foot, 6-inch x 3-foot, 6-inch hatch opening; access rungs are specified, and H-20 highway loading on the cover slab.

2.12 PRECAST CONCRETE STRUCTURES

- A. Precast reinforced concrete structures shall be manufactured by Tindall, Hanson, Oldcastle, or an approved equal. Refer to Drawings for inside dimensions, headroom requirements, and minimum thickness of concrete.
- B. Manufacturer shall notify Engineer at least 5 working days prior to placing concrete during manufacturing process. Engineer may inspect reinforcing steel placement prior to placing concrete.
- C. Structural design calculations and shop drawings shall be prepared and stamped by a professional engineer registered in Georgia.
- D. Design Criteria:
 - 1. Precast concrete:
 - a. The 28-day minimum compressive strength shall be 5,000 psi.

- b. The maximum water content shall be six gallons per 94 pound sack of cement.
 - c. Minimum cement content shall be six 94 pound sacks of cement per cubic yard of concrete.
- E. Manufactured products:
 - 1. Conform to ACI 318 and ACI 350R.
 - 2. Analyze walls and slabs using accepted engineering principals.
 - 3. When "fy" exceeds 40,000 psi, "z" (ACI 318) shall not exceed 95,000 psi. "fs" shall not exceed 50 percent of "fy".
 - 4. Design products to support their own weight, weight of the soil at 120 pcf, and a live load equal to 300 psf applied to top of slab.
 - 5. Cast base slab and walls together to form a monolithic base section.
 - 6. Design structure walls for a water pressure of 90 psf. Originate pressure diagram at finished ground surface.
 - 7. Consider discontinuities in structure produced by openings and joints. Provide additional reinforcing around openings. Frame openings to carry full design loads to support walls.
 - 8. Prevent flotation, with ground water level at finished ground surface, by dead weight of structure and soil load above structure. Do not consider skin friction, soil friction, or weight of equipment in structure.
 - 9. Locate horizontal wall joints 18-inch minimum from horizontal centerline of wall openings.
 - 10. Design structure with a minimum number of joints.
 - 11. Provide lifting hooks for top slab.
 - 12. Locate access openings, wall sleeves, and pipe penetrations as shown on Drawings.
 - 13. Wall sleeves shall be provided by the precast concrete manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify items provided by other sections of Work are properly sized and located.
- C. Verify built-in items are in proper location, and ready for roughing into Work.
- D. Verify correct size of manhole and structure excavation.

3.02 PREPARATION

- A. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.
- B. Do not install manholes and structures where site conditions induce loads exceeding structural capacity of manholes or structures.
- C. Inspect precast concrete manholes and structures immediately prior to placement in excavation to verify manholes and structures are internally clean and free from damage. Remove and replace damaged units.

3.03 INSTALLATION

A. GENERAL

1. Excavation and Backfill:
 - a. Excavate for manholes and structures in accordance with Section 31 00 00 in location and to depth shown. Provide clearance around sidewalls of manhole or structure for construction operations, granular backfill.
 - b. When groundwater is encountered, prevent accumulation of water in excavations. Place manholes or structures in dry trench.
 - c. Where possibility exists of watertight manhole or structure becoming buoyant in flooded excavation, anchor manhole or structure to avoid flotation.

B. MANHOLES

1. Joints of precast sections shall be sealed with approved sealant. After joint has been made, joint opening shall be sealed with grout. Grout shall be applied from both sides of joint and shall be struck smooth and flush on the inside.
2. After installation of pipe to proper grade and alignment, make required seal of pipe and manhole base and formed inverts in accordance with Specifications and as shown on Drawings.

C. PRECAST CONCRETE MANHOLE AND STRUCTURE INSTALLATION

1. Lift precast manholes and structures at lifting points designated by manufacturer.
2. When lowering manholes and structures into excavations and joining pipe to units, take precautions to ensure interior of pipeline and manhole or structure remains clean.
3. Set precast manholes and structures bearing firmly and fully on 6-inch crushed stone bedding, compacted in accordance with provisions of Section 31 00 00 or on other support system shown on Drawings.
4. Assemble multi-section manholes and structures by lowering each section into excavation. Install rubber gasket joints between precast sections in accordance with manufacturer's recommendations. Lower, set level, and firmly position base section before placing additional sections.
5. Remove foreign materials from joint surfaces and verify sealing materials are placed properly. Maintain alignment between sections by using guide devices affixed to lower section.
6. Joint sealing materials may be installed on site or at manufacturer's plant.
7. Verify manholes and structures installed satisfy required alignment and grade.
8. Remove knockouts or cut structure to receive piping without creating openings larger than required to receive pipe. Fill annular space with mortar.
9. Cut pipe to finish flush with interior of manhole or structure.
10. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour as indicated on Drawings.

3.04 TESTING

- A. Test cast-in-place concrete in accordance with Section 03 30 00.
- B. Test precast manhole and structure sections in accordance with Section 33 01 32.

END OF SECTION

SECTION 40 05 07

HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 GENERAL

1.01 DESCRIPTION

- A. This section covers all pipe supports, hangers and brackets necessary to install piping furnished under these Contract Documents. The Contractor shall furnish and install all foundations, anchor bolts, pipe supports, shims, hangers, clamps and hardware required for a complete installation as shown on the Contract Drawings and/or specified herein.

1.02 SHOP DRAWINGS AND ENGINEERING DATA

- A. Complete shop drawings and engineering data shall be submitted to the Engineer in accordance with the requirements of the section entitled "Shop Drawings, Product Data and Samples" of these Specifications.

1.03 STORAGE AND PROTECTION

- A. Pipe supports and accessories shall be stored and protected in accordance with the requirements of the section entitled "General Equipment Stipulations" of these Specifications.

1.04 SHOP PAINTING

- A. Fabricated pipe supports and accessories, except where shown on the Contract Drawings to be galvanized, shall be cleaned and shop primed in accordance with requirements of the section entitled "Painting" of these Specifications.

1.05 GUARANTEE

- A. Provide a guarantee against defective equipment and workmanship in accordance with requirements of Section 01 70 00 Warranties and Bonds of these Specifications.

PART 2 PRODUCTS

2.01 MATERIALS

- A. All supports and hangers shall meet the following material requirements:
 - 1. All structural steel shall conform to ASTM A36.
 - 2. All pipe support columns shall conform to ASTM 53, Grade B, and shall be, at a minimum, Schedule 40.
 - 3. All embedded anchor bolt materials shall conform to ASTM A 193, Grade B8; ASTM A 276, Type 304; or IFI-104, Grade 304. Nuts shall be heavy hex nuts conforming to

ASTM A 194, Grade 8 or IFI-104, Grade 304. Minimum anchor bolt size for pipe supports shall be 1/2-inch diameter.

4. All rod and bolting materials in contact with cold piping (less than -20°F) shall conform to ASTM A 320, Grade B8. Nuts shall be heavy hex nuts conforming to ASTM A 194, Grade 8 or 8T.
5. All rod and bolting materials shall conform to ASTM A 307. Grade B. Nuts shall be heavy hex nuts conforming to ASTM A 307.
6. All carbon steel or malleable iron straps, hangers, clamps, U-bolts, and other hardware in contact with the pipe shall be shop primed, except where specified or shown on the Contract Drawings to be galvanized.
7. Expansion type anchor bolts shall be of 316 stainless steel construction and shall comply with Federal Specification FF-S-325.
8. Long runs of pipe subject to expansion shall be hung by means of adjustable swivel pipe roll hangers, Grinnell, Figure 174; Fee and Mason, Figure 2729; or equal.
9. Short runs of uninsulated pipe subject to expansion in sizes up to and including 3 ½ inches as well as pipe of those sizes not subject to expansion shall be hung by means of adjustable swivel, split pipe ring, Grinnell, Figure 104; Fee and Mason, Figure 199; or equal.
10. Insulated piping and tubing, short lengths of 4 inches and larger pipe subject to expansion, and pipe 4 inches and larger not subject to expansion shall be hung by means of adjustable steel clevis hangers, Grinnell, Figure 260; Fee and Manson, Figure 239; or equal.
11. Pipe 2 inches and less in diameter and not subject to expansion may, when paralleling walls, be supported by single hook clamp hangers, Grinnell, Figure 168; Fee and Mason, Figure 327B, or equal.
12. Flat straphangers will not be permitted. Hangers relying on mastics or adhesives shall not be used.
13. Pipe supported from underneath and subject to expansion shall have adjustable pipe roll stand supports, Grinnell, Figure 274; Fee and Mason, Figure 161; or approved equal. The pipe roll stand shall be supported by concrete piers, structural steel, or steel brackets as required.
14. Pipe supported from underneath and not subject to expansion shall have adjustable pipe supports as shown on the Drawings. Supports shall be properly sized and ample properly grouted floor flanges. Adjustable pipe supports shall be Standon Model S89 Flange Support or Engineered approved equal.
15. Hangers suspended from structural steel shall be anchored on U.F.S. beam clamp, Grinnell, Figure 228L or 2921; Fee and Mason, Figure 252L or 253L; or equal with links as required.
16. Hangers from concrete work shall be secured by universal, galvanized metal inserts, Grinnell, Figure 282; Fee and Mason, Figure 2570; or equal, placed in the concrete at the time of pouring. Wooden plugs or other improvised means shall not be used for any form of hanger fastening.
17. Steel or concrete pipe supports for all piping between undisturbed earth and face of structures shall be in accordance with details shown on the Contract Drawings.
18. All interior and exterior concrete piers shall be Class A concrete meeting the requirements of these Specifications.

19. Rods for supporting suction bells or foot valves of pump intakes shall be stainless steel of the size shown on the Contract Drawings. The rods shall be furnished complete with stainless steel turnbuckles and eyes or other approved means for connection to the suction bell and stainless eyebolt anchored in the concrete. Supports for other pump suction pipelines shall be as shown on the Contract Drawings.
20. Uninsulated copper tubing shall be hung by means of copper-plated, split ring hangers with copper-plated sockets, Grinnell Figure CT-109, Fee and Mason Figure 360, or equal.

PART 3 PART 3 – EXECUTION

3.01 INSTALLATION

- A. Contact between ferrous supports and non-ferrous piping materials shall not be permitted. Supports and clamps shall be rubber coated or copper plated as necessary to prevent this condition.
- B. Adequate supports shall be provided so that there is no movement or visible sagging between supports.
- C. Hangers shall permit a minimum of 1-1/2 inch vertical adjustment after installation.
- D. Hanger rods shall be carbon steel conforming to the following sizes:

Rod Diameter, Inches	Pipe Size, Inches
1/2 and under	1/4 to 2
5/8	2-1/2 to 4
3/4	5 to 8
7/8	10 and up

- E. Carbon steel, alloy steel, stainless steel, and hard-drawn copper pipe shall be supported on maximum intervals as follows:

Pipe Size, Inches	Maximum Interval for Steel, Feet, Liquid	Maximum Interval for Steel, Feet, Gas	Maximum Interval for Copper, Feet
1/2	5	6	4
3/4	6	7	5
1	7	9	6
1-1/2	9	11	8
2	10	13	9

2-1/2	11	14	10
3	12	15	11
4	13	17	-
6	17	21	-
8	19	24	-
10	22	27	-
12	23	29	-
14	25	32	-
16	27	35	-
18	28	37	-
20	30	39	-
24	32	42	-

- F. Annealed copper tubing, polyethylene tubing, and PVC piping shall be supported on maximum intervals as follows:

Tube Size, Inches.	Maximum Interval, feet.
Smaller than 1/2	2
1/2	3
3/4 to 1	4
1-1/4 to 2	5
2-1/2 to 3-1/2	6
4	7
6	8

- G. Where indicated or directed by the Engineer, exposed piping and tubing carrying liquid shall be sloped as necessary to permit complete draining. Pipe deflection between supports shall be considered when determining the slope required to permit complete drainage. All underground piping shall be sloped uniformly for complete drainage.
- H. Cast iron or ductile iron piping shall be supported as recommended by the manufacturer, and at all valves and fittings larger than 4 inches in size as shown on the Contract Drawings. At least one support shall be provided per pipe section or at every other joint, whichever is closer. Supports shall be located next to hubs or bells.
- I. Pipe ends of pipe columns used for support shall be completely covered with a 1/4-inch-thick plate or angle leg welded in place.

- J. All threaded connections installed loose, such as hanger rods and U-bolts, shall have a double nut installation.
- K. Vertical piping shall be supported as shown or required to prevent buckling or swaying utilizing special brackets. Unless otherwise shown, vertical piping shall be supported at the bottom and at each floor. Vertical copper tubing 1 inch and smaller in size shall be supported at 5-foot intervals.
- L. Provide a support within 18 inches of each elbow and within 24 inches of each equipment connection.
- M. Pipes passing through non-load bearing walls and partitions shall not bear on building construction. Pipes shall not be supported from roof decking, bar joists, or ceiling suspension systems unless approved by the Engineer.
- N. Insulation on hot piping (carrying fluids above 70° F) shall be protected at supports and hangers with 12-inch long galvanized steel protection saddle with welded center support. Protection saddle shall be Grinnell Figure 160 or 161, Fee and Mason Figure 171 or 1710, or equal.
- O. Insulation on cold piping (carrying fluids at 70°F or below) shall be protected at supports and hangers by galvanized steel insulation shields with 180 degree contour. Insulation shields shall be Grinnell Figure 167, Fee and Mason Figure 81, or equal.
- P. On insulation finished with an aluminum jacket, a 1/32-inch thick sheet of neoprene shall be provided between the jacket and the shield.
- Q. Hangers shall be selected to fit around insulation.
- R. Following installation all pipe supports shall be field primed and painted with the specified painting system for the application in accordance with requirements of the section entitled "Painting" of these Specifications.
- S. Unless otherwise shown, piping shall not be fastened to a support in such a manner than would prevent axial movement due to thermal expansion and contraction.
- T. No pipe supports shall be anchored to or supported from floor grating.
- U. Unless otherwise noted, piping dimensions shown on the Drawings are for reference only and shall be verified in the field by the Contractor. The Contractor shall size supports and hangers using actual field dimensions.

END OF SECTION

SECTION 40 05 14
POLYVINYL CHLORIDE (PVC) PRESSURE PIPE

PART 1 - GENERAL

1.01 SCOPE

- A. The work covered by this section includes furnishing all labor, equipment, and materials required to install and test polyvinyl chloride (PVC) pressure, pipe, including valves, unions, fittings, couplings, adapters, and accessories, as shown on the Drawings and/or specified herein.
- B. The Contractor's attention is called to the fact that all PVC piping and accessories are not necessarily shown completely on the Drawings which are more or less schematic. However, the Contractor shall furnish and install all piping indicated or required for proper operation of the equipment or services requiring such piping.

1.02 QUALITY ASSURANCE

- A. The Contractor, at the Engineer's request, shall furnish a certificate from the manufacturer of the pipe and fittings that the manufacturer is fully competent and capable of manufacturing PVC pipe and fittings of uniform texture and strength that will fully comply with these specifications and have so manufactured this class of pipe in sufficient quantities to be certain that it will meet all normal field conditions of usage. The manufacturer must have adequate equipment and quality control facilities to be sure that each extrusion of pipe is uniform in texture, dimensions, and strength.
- B. All pipe shall be tested and inspected at the place of manufacture for all requirements of the latest ASTM and Commercial Standard tests and certified copies of the test reports covering each shipment shall be submitted to the engineer prior to laying.
- C. Each length of pipe and each fitting shall have the following data clearly marked on each piece:
 - 1. Nominal size
 - 2. Type and grade of material and ASTM standard
 - 3. SDR, class, or schedule rating
 - 4. Manufacturer
 - 5. National Sanitation Foundation's seal of approval

1.03 SHOP DRAWINGS AND ENGINEERING DATA

- A. Complete shop drawings and engineering data shall be submitted to the Engineer in accordance with requirements of the section entitled "Submittal Procedures" of these Specifications.

1.04 STORAGE AND PROTECTION

- A. PVC piping and accessories shall be stored and protected in accordance with the requirements of the section entitled "Product Requirements" of these Specifications.
- B. PVC pipe and fittings shall be stored under cover.

- C. All pipe and accessories shall be stored aboveground and fully supported so as not to bend or deflect excessively under its own weight. Height of stacked pipe shall not exceed 4 feet. Bundled pipe shall not be stacked more than two bundles high.
- D. Kinked, flattened, buckled, broken, or otherwise defective pipe and fittings shall not be used.
- E. Pipe shall be handled using nylon slings. Wire rope slings or chains shall not be used.

1.05 GUARANTEE

- A. Provide a guarantee against defective equipment and workmanship in accordance with the requirements of the section entitled "Execution and Closeout Requirements" of these Specifications.

PART 2 - PRODUCTS

2.01 PVC PIPE AND FITTINGS

- A. The pipe and fittings shall be homogenous throughout and free from visible cracks, holes, foreign inclusions, or other injurious defects. The pipe shall be as uniform as commercially practical in color, opacity, density, and other physical properties.
- B. The manufacturer shall provide waterstops, acceptable to the Engineer, which shall be applied to the outside of plastic pipe when the pipe is to be enclosed in any structure where concrete or mortar is used which will prevent leakage along the outer wall of the barrel of the pipe.
- C. No single piece of pipe shall be laid on any project covered by this specification unless it is found to be generally straight. Such pipe shall have a maximum ordinate as measured from the concave side of the pipe not to exceed 1/16 inch per foot of length. If the deviation from straightness exceeds this requirement, then the particular piece of pipe shall be rejected for use until it can comply with this provision.
- D. Wyes, tees, bends, and adapters and any other fittings required or directed by the Engineer shall be constructed of ductile iron as directed in the section entitled "Ductile Iron Process Pipe" of these Specifications. Engineering data for such fittings showing cross-sectional views with dimensions provided and such data and fittings shall be approved by the Engineer prior to their use. The materials used in the manufacture of fittings shall conform to the requirements for the pipe with which they shall be used and any variation of such requirements shall be subject to the approval of the Engineer. Fittings shall have wall thickness equal to or greater than that of the pipe to which they are joined.

2.02 PIPE

- A. PVC pipe shown on the Drawings to be installed outside of structures or buried underground and used to convey water or wastewater shall have push-on joints unless otherwise noted on the Drawings. All pipe material shall be Grade 1, Type I, polyvinyl chloride (PVC) in accordance with ASTM D 1784, Class 12454-B. All pipe material shall be National Sanitation Foundation approved for use with potable water. Unless noted otherwise on the Drawing the following shall apply, pipe in sizes 1-½ inches through 3 inches (1-½ inches through 12 inches for corrosive fluids) shall be SDR 21 with 200 psi pressure rating in accordance with ASTM D 2241. Pipe in sizes 4 inches through 12 inches shall be either SDR 21 with 200 psi pressure rating in accordance with ASTM D 2241 or Class 200 in accordance with AWWA C 900, depending on which is called for on the Drawings or in the Bid Schedule. Maximum lengths of pipe shall not exceed 20 feet.
- B. PVC pipe shown on the Drawings to be installed inside of structures or used to transport

chemicals and liquid or gaseous chlorine shall have threaded joints or solvent welded joints. PVC shall be Schedule 80, conforming to the latest requirements of ASTM D1784 and ASTM D1785 and NSF 14/61.

- C. PVC pipe threads shall comply with ANSI B1.20.1.
- D. Solvent used for joining PVC pipe and fittings shall comply with ASTM D2564.
- E. When operating temperatures exceed 140 degrees F, pipe material shall be chlorinated polyvinyl chloride (CPVC) in accordance with ASTM D 1784, Type 4, Grade 1, Class 23477-B.

2.03 FITTINGS

- A. All fittings 4-inches and larger in PVC piping system conveying water or wastewater shall be ductile iron as specified in the section entitled "Ductile Iron Pipe" of these Specifications unless otherwise shown on the Drawings. Engineering data for fittings showing cross-sectional views with dimensions shall be provided and such data and fittings shall be approved the Engineer prior to their use. Connections between cast iron or ductile iron fittings and PVC pipe shall be made by use of special adapters similar to Mueller Transition Gland A-399 by Mueller Co., Transition Gasket F6340 by Clow Corporation or a similar transition which has been approved by the Engineer. The joint shall be mechanical joint for ductile iron or cast iron as described in the section entitled "Ductile Iron Pipe" of these Specifications.
- B. Fittings for PVC pipe inside of structures or used to convey liquid or gaseous chlorine shall comply with the requirements of ASTM D 2467 for Moulded, Schedule 80.
- C. Flanges shall be furnished with 1/8-in. thick full-faced gaskets. Flange bolts and nuts shall be ASTM A276, Type 304 or 316 stainless steel. Flanges shall be threaded or socket welded to pipe ends, shall be true 90° with the pipe axis, and shall conform to ANSI 150-lb. Design.

2.04 PVC VALVES AND STRAINERS

- A. Unless otherwise shown or required, all valves, unions and strainers in PVC piping shall be constructed of Type I, Grade 1 PVC. Valves shall be NSF approved and shall have a working pressure of 150 psi.
- B. Ball valves shall have double union type body, Teflon seats, Viton seals, full diameter port, and NPT threaded ends. Ball valves in 4-inch size may have single union body.
- C. Check valves shall be of the ball type with union body, Viton seat, and NPT threaded ends.
- D. Strainers shall be of the wye type with NPT threaded ends and 8 or 10 mesh strainer basket.

2.05 PLASTIC VALVES

- A. General
 - 1. All valves shall be certified as completely compatible with the intended and specified service; compatibility shall apply to the material of the valve and internal components, including all seals, gaskets, O-rings and washers; solvents and primers used in valve joint make-up shall be specifically in conformance with the written instructions of the valve supplier. Service chemicals and service conditions are shown on the Drawings and are described in the piping specifications in Division 40.
 - 2. Except as otherwise specified valve ends shall be socket-type designed for solvent welding. The valve manufacturer shall provide specific recommendations for solvent and primer.

3. Valve material shall be the same as the piping service except as specified.
 - a. PVC shall be Type 1, cell classification 12454, per ASTM D1784 classification, made from unplasticized polymer, and generally suitable for service to 140° F.
 - b. CPVC shall be Type 4, cell classification 23447, per ASTM D1784, classification generally suitable for service to 200° F.
 - c. Polypropylene (PP) shall conform to the material requirements of ASTM D4101 for copolymer polypropylene.
 - d. PVDF (polyvinylidene fluoride) shall be manufactured from high molecular weight polymers of vinylidene fluoride.
 - e. The manufacturer of the valves shall retain material source quality documentation and shall furnish it to the ENGINEER upon request.
4. Unless otherwise specified:
 - a. O-rings, valve seats and stem seals shall be EPDM, Viton, Teflon, or Teflon encapsulated elastomer. Alternative materials may not be substituted without complete documentation provided to the ENGINEER of service suitability.
 - b. Gaskets shall be made from PTFE-bonded sheet material, GORE-TEX manufactured by W.L. Gore & Associates, AV Low-Torque gaskets by Asahi of America, or equal.
 - c. Valve external hardware shall be Type 316 stainless steel. No internal metallic components shall be exposed to the service fluid.
 - d. No factory or field coatings shall be applied to the valves.
5. All valves, except butterfly valves shall have a non-shock service pressure rating of not less than 150 psi at 73 degrees F.
6. All valves shall be given hydrostatic, pressure and leakage tests at the factory. Provide certified copy of test results.
7. Valves shall be the standard, catalogued products of the following manufacturers:
 - a. Spears Manufacturing Company
 - b. Asahi/America
 - c. Chemtrol/Nibco
 - d. Hayward
 - e. Plast-O-Matic
8. Valves specified as furnished with equipment or equipment systems shall comply with these requirements.

B. Ball Valves

1. Ball valves shall be of the double-union, socket-ended, threaded or flanged type as required, with full-port, full flow openings. Valves 1/4-in to 4-in for non-buried service shall be true union type. Buried valves 6-in and smaller shall be solvent cement welded joint type.
2. Provide quarter-turn manual valve operator and valve seat adjustability.

3. Plastic valves in sodium hypochlorite service shall have the ball drilled to permit venting of pressure and gas from the confined ball cavity, when the valve is closed. The drilling shall vent to the upstream end of the valve. The drilling shall be 1/8-in opening, deburred.
- C. Butterfly Valves
1. Valves shall have PVC, CPVC or PP body and disc, with EPDM, Viton, or Teflon seat and Teflon O-ring shaft seals fully isolating a Type 316 or Type 403 stainless steel stem.
 2. The valves shall be of the modified lug, true lug, or wafer style, suitable for dead-end service.
 3. Each valve shall be furnished with a lever operator with built-in lockout and indexing capability.
- D. Diaphragm valves
1. Valves shall have flanged, socket or spigot, threaded, or double-union ends as required.
 2. Valve body and bonnet shall be of solid PVC, CPVC, PP, or PVDF to match piping.
 3. Diaphragms shall be Teflon, EPDM, Viton, Buna-N, Butyl, Hypalon, Neoprene, or Natural Rubber to suit the specific service.
 4. The valve shall have a full-width weir, designed for throttling, and complete bubble-tight closure rated to a minimum of 150 psi at 73° F.
 5. Provide a handwheel operator with a clear plastic stem cover and a position indicator.
- E. Needle Valves shall be designed for close control of flow throttling with a multi-turn valve handle.
- F. Check Valves
1. Ball check valves shall be double-union style with socket ends, solid and completely spherical ball and capable of either horizontal or vertical mounting.
 2. Swing Check valves shall be flanged, full-ported, with top entry access for disc inspection and removal. Furnish with outside lever and weight, with weight position along lever arm adjustable. Furnish with counterweights, as required.
- G. Backpressure Regulating/Control Valves
1. Spring-loaded diaphragm design, fully adjustable pressure setting, set to assure continuous positive pressure at the pump discharge.
 2. Furnish with Teflon diaphragms and elastomer-coated springs.
- H. Pressure Relief Valves
1. Angle-pattern design, with adjustable relief pressure and locking nut. Spring-loaded, with pressure adjustable over range up to 100 psig.
 2. The valve spring shall be elastomer-coated and isolated from the process flow. Provide Teflon diaphragms.
 3. Relief valves shall be piped as indicated, and if not indicated, the relief piping shall be directed to the floor or adjacent gutter or drain.

4. Pressure relief valve settings shall be set to a pressure as recommended by the pump or equipment supplier and adjusted at the time of equipment testing, inspection and start-up.

2.06 JOINTS

A. Push-On Joints

1. The joints shall be designed so that the pipe and fittings may be connected on the job without the use of solvent cement or any special equipment. The push-on joint shall be single rubber gasket joint designed to be assembled by the positioning of a continuous, molded, rubber ring gasket in an annular recess in the pipe or fitting entering pipe into the socket thereby compressing the gasket radially to the pipe to form a positive seal. The gasket and the annular recess shall be so designed and shaped that the gasket is locked in place against displacement as the joint is assembled. Details of the joint design and assembly shall be in accordance with the joint manufacturer's standard practice. The joints shall be designed so as to provide for the thermal expansion or contraction experienced with a total temperature change of at least 75 degrees F in each joint per length of pipe. The joint shall comply with ASTM D 3139. Gasket shall comply with ASTM F 477.
2. Lubricant furnished for lubricating joints shall be nontoxic, shall not support the growth of bacteria, shall have no deteriorating effects on the gasket or pipe material, and shall not impart color, taste, or odor to water. The lubricant containers shall be labeled with the manufacturer's name.
3. Gaskets shall meet all applicable requirements of ANSI A21.11. Gasket dimensions shall be in accordance with the manufacturer's standard design dimensions and tolerances. The gasket shall be of such size and shape as to provide an adequate compressive force against the spigot and socket after assembly to effect a positive seal under all combinations of joint and gasket tolerances. The trade name or trademark, size, mold number, gasket manufacturer's mark and year of manufacture shall be molded in the rubber on the back of the gaskets.
4. Gaskets shall be vulcanized natural or vulcanized synthetic rubber. No reclaimed rubber shall be used. When two hardnesses of rubber are included in a gasket, the soft and hard portions shall be integrally molded and joined in a strong vulcanized bond. They shall be free of porous areas, foreign material, and visible defects. The required properties of the gasket rubber and the required method of test are given in the following table:

Property	ASTM Test Method	Main Body of Gasket	Harder Portion (if used)
Hardness, Durometer	D676 at "A" 76 + 6° F	45-70	78-90
Minimum Ultimate Tensile, psi	D412	2,000	1,200
Minimum Ultimate Elongation, %*	D412	300	125
Minimum Aging, %**	D 572***	60	60
* Of original length. ** Of original values of tensile and ultimate elongation. *** Oxygen pressure method: After 96 hours at $70 \pm 1^\circ \text{C}$ at 300 +10 psi.			

5. The gasket manufacturer shall set up such quality control procedures as will insure the gasket's meeting the requirements of this standard. He shall furnish a monthly report of representative quality control test results to the pipe manufacturer.
6. A sample push-on fitting shall be submitted to the Engineer for examination and approval prior to delivery of any pipe.

B. Threaded Joints

1. Joints shall be made with American Standard IPS threads. All joints shall be made up with Teflon thread tape or thread dope.

PART 3 - EXECUTION

3.01 LAYING PIPE

- A. All provisions with respect to trenching, backfilling, bedding, and pipe laying shall conform to the applicable requirements of the sections entitled "Earthwork" and "Ductile Iron Pipe" of these Specifications.
- B. All provisions with respect to connections and existing utilities shall comply with the applicable requirements of the section entitled "Ductile Iron Piping and Fittings" of these Specifications.
- C. Exposed piping shall be supported in accordance with the requirements of the section entitled "Hangers and Supports for Process Pipe" of these Specifications. Metal valves and valve boxes shall be supported independently of piping. PVC piping shall be isolated from direct contact with metal or concrete supports by a 1/32 – inch sheet of neoprene.
- D. When a joint consists of a PVC flange and a metal flange, the metal flange shall be flat faced and furnished with a full-face resilient gasket.
- E. PVC valves shall be installed with the flow arrow in the proper direction. Union nuts on PVC valves shall be tightened only hand tight in accordance with manufacturer's instructions. Spare O-ring seals and seats shall be furnished with each PVC valve.
- F. Where specifically shown or called for on the Drawings, service line taps into PVC pipe shall be made using tapping saddle constructed for use on PVC pipe. The saddle shall be constructed of bronze or brass, shall have all stainless steel bolts or screws, and have a resilient rubber gasket to provide a positive, watertight seal.
- G. PVC pipe laid underground shall have a minimum of 48-inches of cover in traffic areas and 36-

inches of cover in non-traffic areas. Under ground installations shall be in accordance with ASTM D2774.

3.02 FIELD TESTING

- A. After all piping has been placed and backfilled between the joints, each run of newly laid pipe, or any valved section thereof, shall be tested by the Contractor in the presence of the Engineer, and tests shall be continued until all leaks have been made tight to the satisfaction of the Engineer.
- B. All piping shall be subject to a hydrostatic gauge pressure equal to the 150 psi. All chemical lines, hot and cold potable water lines shall have zero leakage. All other applications, the allowable leakage shall be as shown in Table 1. The duration of the test shall be a minimum of 2 hours.
- C. The Contractor shall take all precautions necessary to protect any equipment that might be damaged by the pressures used in the tests. Delicate equipment shall be valved off, removed, or otherwise protected.
- D. All piping shall be securely anchored and restrained against movement prior to application of test pressures. Prior to the pressure test, pipe laid in trenches shall be partially backfilled adequately to secure the pipe during the test. All joints, fittings, and valves will be left open where possible. All exposed pipe, fittings, valves, and joints shall be carefully examined during the pressure test.
- E. Before applying the specified test pressure, all air shall be expelled from the pipe. If hydrants, blow-offs, or air release valves are not available at the high places, the Contractor shall make the necessary taps at points of highest elevation before the test is made and insert plugs after the test has been completed.
- F. Any excessive leakage developing during the test shall be corrected at the Contractor's expense. If the defective portion cannot be located, the Contractor, at his expense, shall remove and reconstruct as much of the original work as necessary to obtain a facility meeting the specified leakage limits.
- G. After all test on any section have been completed to the satisfaction of the Engineer, the Contractor shall carefully clean, blow out, and drain the line of all water to prevent freezing of the same. The Contractor shall also demonstrate to the satisfaction of the Engineer that any and all lines are free from obstructions and foreign material.
- H. The Contractor shall bear complete cost of the tests, including set-up, labor, temporary piping, blocking, gauges, bulkheads, water, air, soap solutions, and any other materials required to conduct the tests.
- I. All pipe used for gaseous chlorine shall be tested with ammonia solution as recommended by the manufacturer of the chlorination equipment.

TABLE 1

Allowable Leakage - Gallons per Hour per 100 Joints				
Pipe Diameter (inches)	Test Pressure (psi)			
	50	100	150	200
4	0.35	0.50	0.60	0.75
6	0.53	0.75	0.90	1.10
8	0.70	1.00	1.20	1.40
10*	0.88	1.25	1.50	1.75
12*	1.05	1.50	1.80	2.10

* Single-gasket coupling is one joint. Twin-gasket coupling is two joints.

3.03 DISINFECTION

- A. After installation and testing, all potable water piping shall be disinfected in accordance with the requirements of the section entitled "Disinfecting of Potable Water Utility Distribution" of these Specifications.

3.04 FIELD PAINTING

- A. All installation, all exposed piping shall be field primed and painted in accordance with the requirements of the section entitled "Painting and Coating" of these Specifications.

END OF SECTION

SECTION 40 05 17

COPPER PROCESS PIPE AND TUBING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment, and incidentals required and install, complete and ready for operation, and field test all copper pipe, copper tubing, and appurtenances as shown on the Drawings (including all buried copper piping and copper piping within buildings and structures) and as specified herein.
- B. Pipe for all potable, non-potable, protected, and flush/seal water systems shall be Cu₂ (ASTM B88, Type K), drawn temper H80, with Type CF-2 or CF-3 fittings.
- C. Pipe for buried potable, non-potable, protected and flush/seal water systems shall be Cu₁ (ASTM B88, Type K), drawn temper H80, with Type CF-2 or CF-3 fittings.
- D. Pipe for compressed air systems shall be Cu₂ (ASTM B88, Type k), drawn temper H80, with Type CF-3 fittings.
- E. Pipe for drainage, waste, and vent systems shall be Cu₃ (ASTM B306, Type DWV), drawn temper H80, with Type CF-7 fittings.

1.02 RELATED WORK

- A. Section 09 90 00 Painting and Coating
- B. Section 01 60 00 Product Requirements
- C. Section 40 05 52 Process Valves
- D. Section 40 05 07 Hangers and Supports for Process Piping
- E. Section 40 41 13 Process Pipe Insulation
- F. Division 22 Plumbing

1.03 SHOP DRAWINGS AND ENGINEERING DATA

- A. Complete shop drawings and engineering data on all piping and accessories shall be submitted to the Engineer in accordance with requirements of the section entitled "Submittal Procedures" of these Specifications.

1.04 STORAGE AND PROTECTION

- A. Piping and accessories shall be stored and protected in accordance with requirements of the section entitled "Product Requirements" of these Specifications.

1.05 FIELD PAINTING

- A. Unless otherwise specified herein, all exposed copper pipe and tubing shall be cleaned and painted in accordance with Section 09 90 00 of these Specifications.

1.06 REFERENCE STANDARDS

- A. Design, manufacturing and assembly of elements of the products herein specified shall be in accordance with the standards of the below listed organizations.
 - 1. American Society for Testing and Materials (ASTM)
 - a. ASTM B32 – Standard Specification for Solder Metal

- b. ASTM B42 – Standard Specification for Seamless Copper Pipe, Standard Sizes
 - c. ASTM B62 – Standard Specification for Composition Bronze or Ounce or Ounce Metal
 - d. ASTM B75 – Standard Specification for Seamless Copper Tube
 - e. ASTM B88 – Standard Specification for Seamless Copper Water Tube
 - f. ASTM B280 – Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
 - g. ASTM B306 – Standard Specification for Copper Drainage Tube (DWV)
2. American Society of Mechanical Engineers (ASME)
- a. ASME B16.15 – Cast Bronze Threaded Fittings Classes 125 and 250
 - b. ASME B16.18 – Cast Copper Alloy Solder Joint Pressure Fittings
 - c. ASME B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - d. ASME B16.23 – Cast Copper Alloy Solder Joint Drainage Fittings (DWV)
 - e. ASME B16.24 – Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150, 300, 400, 600, 900, 1500, and 2500.
 - f. ASME B16.26 – Cast Copper Alloy Fittings for Flared Copper Tubes
 - g. ASME B16.29 – Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings (DWV)
- B. Where reference is made to a standard of one of the above, or other organizations, the version of the standard in effect at the time of bid opening shall apply.

PART 2 - PRODUCTS

2.01 PIPE AND TUBING

- A. Copper pipe, Cu1, shall conform to ASTM B88, Type K.
- B. Copper pipe, Cu2, shall conform to ASTM B88, Type L.
- C. Copper pipe, Cu3, shall conform to ASTM B306, DWV, Temper H.
- D. Copper pipe, Cu4, shall conform to ASTM B42, Temper H80, drawn.
- E. Copper pipe, Cu5, shall conform to ASTM B75, Type C12200 (DHP), seamless, deoxidized.
- F. Copper pipe, Cu6, shall conform to ASTM B280, deoxidized and dehydrated.

2.02 FITTINGS

- A. Type CF-1, cast bronze, threaded adapters, 150 lb., screwed, ASTM B62, ANSI/ASME B16.15.
 - 1. Type CF-2, brass tube solder type, ASTM B62, ASME B16.18.
- B. Type CF-3, wrought copper, solder type, ASTM B75, ASME B16.22 standard.
- C. Type CF-4, cast brass or bronze recessed drainage pattern, ASME B16.23.
- D. Type CF-5, flange fittings, 150 lb, ASME B16.24
- E. Type CF-6, 125 lb, flared or compression type copper unions, ASME B16.26.

- F. Type CF-7, soldered cast brass or wrought copper drainage pattern, ASME B16.29.
- G. Type CF-8, 125 lb, bronze unions with ground joint seats, ASTM B62.
- H. Type CF-9, flareless unions, Parker "Intru-lok", Crawford "Swagelok" or equal.

2.03 JOINT MATERIALS

- A. Type S-1, Solder Alloy 95TA (95% Tin, 5% Antimony), ASTM B32. No solder containing lead shall be utilized on the project.
- B. Type S-2, brazing filler metal classified as Bcu4 or Bcu5, with minimum melting point of 1300 degrees F. Use wrought fittings for brazing.

PART 3 - EXECUTION

3.01 JOINING OF PIPE

A. Flanged Connections

1. All flange faces shall be in perfect alignment with the holes straddling the vertical centerline of the piping.
2. All bolts shall be well lubricated over the entire thread length with a heavy graphite and oil mixture prior to the tightening operation. Bolts shall be tightened with proper wrenches, care being taken to secure uniform pressure on the bolts and gasket and to avoid overstressing of the bolts, dishing of the flanges, and compression of the gasket beyond its proper limits. Commercial grade carbon steel bolts, ASTM A307, Grade B shall be tightened to obtain approximately 15,000-psi stress based on the root area of the thread. Alloy steel bolts, ASTM A1936, Grade B7 shall be tightened to obtain a stress of 45,000-psi.
3. All bolts shall be of sufficient length so that when fully tightened, a minimum of two full threads shall extend beyond the nut.

B. Screwed Connections

1. All screwed connections shall have full thread of true taper, accurate to gauge, and conform to ANSI B2.
2. Reduction in size shall be made using reducing fittings.
3. The use of bushings or close nipples is prohibited.
4. Plugs shall be steel or brass with square head.
5. Screwed joints shall be made with an approved joint compound applied to the male thread only. Caulking of screwed joints will not be allowed.

C. Soldering (Copper Tubing)

1. Tubing shall be cu with square ends and reamed to prevent burrs, out-of-round or improperly sized ends.
2. After cutting, all surfaces to be soldered shall be thoroughly cleaned to a metal-bright finish, free from dirt, grease or other material before fluxing and soldering. This cleaning shall be performed by using emery cloth, sandpaper or steel wool. Clean the outside end of the tubing for a length of ½-inch greater than the depth of the fitting. The inside of the fittings shall be cleaned in a similar manner. Apply non-corrosive flux and assemble the joint. Acid solder or acid flux will not be allowed.

3. The surfaces to be joined shall be heated up slowly and uniformly to the melting point of the solder. The surface being soldered shall be maintained above the melting point of the solder for sufficient time to draw the solder completely into the joint. When the solder congeals to a plastic state the excess metal shall be removed with a cloth brush, leaving a fillet around the end of the fitting. Full penetration of the solder uniformly throughout the entire socket is required. The soldered joints shall be allowed to cool in still air. Quenching will not be permitted.
4. Any type of crack, pinhole, area of incomplete penetration, or similar defect will not be accepted. Penning for closing up defects will not be permitted.
5. Heating torches of sufficient size equipped with multiple tips or ring burners for use on combination torches, shall be used for heating of large fittings of 2-inch diameter and larger prior to soldering.
6. Remove all external and internal loose solder and flux after joint cools.

D. Brazing

1. Cutting and cleaning of tubing shall be as specified for soldering operations.
2. Apply flux in accordance with recommendations of manufacturer of brazing filler material being used. Apply to outside of fitting and heat affected area of tubing. Avoid getting flux inside tube. Flux may be omitted when joining copper tubes to wrought copper fittings but is required for joining to cast (bronze) fittings.
3. Assemble joint by inserting tube into socket hard against stop and turning.
4. Heat parts to be joined beginning 1-inch from edge of fitting, continuously moving the flame. When flux at fitting is quiet and transparent, maintain heat along joint by moving flame along axis between fitting and tubing.
5. Apply brazing material at point where tubing enters socket of fitting. Avoid putting flame on brazing material. Heated joint should melt brazing material and capillary action will draw material into the joint. When joint is properly made, a fillet of filler metal will be visible completely around the joint. Stop adding filler metal when fillet is formed.
6. After brazing material has solidified, clean off flux residue. Fittings must cool naturally. Quenching will not be allowed.
7. Any type of crack, pinhole, area of incomplete penetration, or similar defect will not be accepted. Penning for closing up defects will not be permitted.
8. Where possible, all buried service shall be continuous, free from fittings. Fittings, where required, shall conform to ANSI B16.18 or B16.22 for solder joint pressure fittings. Brazing will be the only acceptable method for joining these fittings. The system components, tubing, fittings and brazed joints shall have a minimum working pressure of 150 psi at 200° F.

3.02 INSTALLATION - GENERAL

- A. Copper pipe, tubing and fittings shall be installed in a neat and workmanlike manner in accordance with the best practices and methods. Piping shall be installed true to alignment and shall be adequately supported. Each length of pipe shall be thoroughly cleaned before installation. Care shall be taken to insure that stresses are not imposed on the pipe during installation.

- B. Installation methods and supports for the pipe shall be in complete accordance with the manufacturer's recommendations.
- C. Piping shall have a sufficient number of unions or couplings to allow for the convenient removal of sections of piping without disturbing the remainder of the system. Unions and couplings shall be provided close to pieces of equipment and in-branch lines to permit ready dismantling of piping without disturbing the main pipeline or adjacent branch run.
- D. Each section of piping shall be laid out and all connections made while the pipe is held in temporary supports. After completion of connections, pipe shall be clamped in position on its permanent supports.
- E. **Systems shall be arranged with low points to permit drainage of the system.**
- F. Threaded joints shall be made up perfectly tight with a stiff mixture of graphite and mineral oil or an approved nontoxic, non-hardening pipe joint compound applied to the male thread only.

3.03 TESTING

- A. Copper piping and tubing shall be tested for at least 2 hours at a pressure of 125 psi. If any joint of pipe section is found to be defective, it shall be repaired or replace and retested, at no change in Contract Price or Time.

END OF SECTION

SECTION 40 05 19

DUCTILE IRON PROCESS PIPE

PART 1 - GENERAL

1.01 SCOPE

- A. Work covered by this section includes furnishing all labor, equipment, and materials required to furnish, install, and test ductile iron piping, including all fittings, wall pipe and sleeves, couplings, toppings, anchor blocks, and accessories, as specified herein and/or shown on the Drawings.

1.02 QUALITY ASSURANCE

- A. The Contractor shall submit to the Engineer written evidence that the pipe furnished under this Specification is in conformance with the material and mechanical requirements specified herein. Certified copies of independent laboratory test results or mill test results from the pipe supplier may be considered evidence of compliance provided such tests are performed in accordance with the appropriate ASTM or AWWA testing standards by experienced, competent personnel. In case of doubt as to the accuracy or adequacy of mill tests, the Engineer may require that the Contractor furnish test reports from an independent testing laboratory on samples of pipe materials.
- B. Each ductile iron pipe length and fitting shall be clearly marked with the pressure rating, metal thickness class, heat mark, net weight (excluding lining or coating) and name of the manufacturer. In addition, each item of piping shall be marked with an identifying mark corresponding to the appropriate mark on the shop drawings for that particular item of piping.

1.03 SHOP DRAWINGS AND ENGINEERING DATA

- A. Complete shop drawings and engineering data on all piping and accessories shall be submitted to the Engineer in accordance with requirements of the section entitled "Shop Drawings, Product Data and Samples" of these Specifications.

1.04 STORAGE AND PROTECTION

- A. Piping and accessories shall be stored and protected in accordance with requirements of the section entitled "Product Requirements" of these Specifications.

1.05 SHOP PAINTING

- A. Unless otherwise specified herein, all buried ductile iron pipe and fittings and cast iron fittings shall be cleaned and provided with a bituminous coating all exposed or submerged shall be shop primed per the section entitled "Painting and Coating" of these specifications and cement lining applied at the factory.

PART 2 – PRODUCTS

2.01 GENERAL

- A. No broken, cracked, deformed, misshapen, imperfectly coated, or otherwise damaged or defective pipe or fittings shall be used. All such material shall be removed from the site of the work. All piping shall be new and unused.
- B. Ductile iron pipe shall be manufactured by American Cast Iron Pipe Co., U.S. Pipe & Foundry Co., Griffin Pipe Co. or Engineer approved equal.
- C. Unless otherwise shown on the Drawings or directed by the Engineer, the nominal pipe wall

thickness and pressure class of pipe shall be as follows:

Pipe Size	Pressure Class	Wall Thickness (in.)
3-inch Ductile Iron	350	0.25
4-inch Ductile Iron	350	0.25
6- inch Ductile Iron	350	0.25
8-inch Ductile Iron	350	0.25
10-inch Ductile Iron	350	0.26
12-inch Ductile Iron	350	0.28
16-inch Ductile Iron	300	0.32
18-inch Ductile Iron	300	0.34
20-inch Ductile Iron	300	0.36
24-inch Ductile Iron	300	0.40
30-inch Ductile Iron	300	0.45
36-inch Ductile Iron	300	0.51
42-inch Ductile Iron	300	0.57
48-inch Ductile Iron	300	0.64
54-inch Ductile Iron	300	0.72
60-inch Ductile Iron	300	0.76
64-inch Ductile Iron	300	0.80

2.02 DUCTILE IRON PIPE

- A. Ductile iron pipe shall be designed in accordance with ANSI A21.50, Thickness Design of Ductile Iron Pipe, using 60,000 psi tensile strength, 42,000 psi yield strength, and 10 percent elongation.
- B. Ductile iron pipe shall be manufactured in accordance with ANSI A21.51, Ductile Iron Pipe Centrifugally Cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids, and shall be made of ductile iron having a minimum tensile strength of 60,000 psi, a minimum yield strength o 42,000 psi and 10 percent minimum elongation.

2.03 DUCTILE IRON FITTINGS

- A. All fittings shall conform in every respect to AWWA C110 or C153 as applicable, 2 inches through 64 inches, for Water and Other Liquids.
- B. Unless otherwise shown on the Drawings, directed or specified, all fittings shall have the same pressure rating, as a minimum, of the connecting pipe.
- C. Design of all fittings, whether long or short pattern, shall be as indicated or dimensioned on the Drawings. Special fittings and ductile iron wall pipes and sleeves shall conform to the dimensions and details shown on the Drawings.
- D. All grooved-end fittings shall conform to the laying length requirements of ANSI A21.10 or ANSI A21.53.

2.04 JOINT FOR DUCTILE IRON PIPE AND FITTINGS

- A. General

1. Joints for ductile iron pipe and fittings shall be mechanical joints, flanged joints, or push-on joints, as shown on the Drawings or specified herein.
2. Unless otherwise shown on the Drawings, specified or directed, all ductile iron pipe laid underground shall be joined using mechanical joints or push-on type joints.

B. Mechanical Joints

1. Mechanical joints shall consist of a bolt joint of the stuffing box type as detailed in ANSI A21.10 and described in ANSI A21.11.
2. Mechanical joints shall be thoroughly bolted in accordance with the manufacturer's recommendations with Tee Head Bolts and bolts of high strength, heat treated cast iron containing 0.50 copper or high strength low-alloy steel having a minimum yield point strength of 40,000 pounds per square inch and an ultimate tensile strength of 70,000 pounds per square inch.
3. Gaskets and bolts and nuts shall conform to ANSI A21.11. Gaskets shall be of styrene butadiene (SBR). Gaskets for high temperature service and air shall be Viton.
4. Glands shall be of high strength ductile iron.

C. Flanged Joints

1. Flanged joints shall conform to ANSI B16.1, Class 125, and in accordance with Table 10.23 of ANSI A21.10.
2. Flanged joints shall be bolted with through stud or tap bolts of required size as directed. Bolts and nuts shall conform in dimensions to the American Standard heavy series. Nuts shall be hexagonal, cold pressed. Bolts and nuts shall conform to ASTM A 307, Grade B.
3. Gaskets shall be SBR rubber or other approved quality shall be used in all flanged joints. Gaskets shall conform to the requirements of ANSI A21.11/AWWA C111.
4. Flanges on ductile iron pipe longer than 12 inches may be of the screw type. Pipe threads shall be of such length that with flanges screwed home, the end of the pipe shall project beyond the face line of the flange. Flange and pipe shall then be machined to give a flush finish to the pipe and the flange and surface shall be normal to the axis of the pipe. Ductile iron flanges shall be of such design that the flange neck completely covers the threaded portion of the pipe to protect same against corrosion. Flange faces on cast iron fittings shall be coated with white lead immediately after they have been faced and drilled. All pipe with screw type flanges shall be assembled, faced, and drilled at the point of manufacture, unless otherwise approved by the Engineer.
5. Where tap or stud bolts are required, flanges shall be drilled and tapped accordingly.

D. Push-On Joints

1. Push-on joints shall conform to ANSI A21.11. Details of the joint design shall be in accordance with the manufacturer's standard practice such as "Fastite," "Bell-Tite," or "Tyton" joints.
2. Gaskets shall be SBR unless otherwise specified.

E. Restrained Joints

1. Restrained joints shall meet all requirements of ANSI/AWWA C110/A21.10. Joints shall be pressure rated for a minimum of 250 psi. Restrained joints may be American "Flex-

Ring”, “Lok-Ring” or “Fast-Grip”, US pipe “TR Flex” or “Field Lok”; or “MEGALUG” as manufactured by EBAA Iron, Inc.

2.05 PIPE COATING AND LINING

- A. All ductile iron pipe and fittings buried underground shall have an asphaltic coating on the pipe exterior approximately one (1) mil thick per AWWA C151 for ductile iron pipe and AWWA C110 and C153 for fittings. All submerged ductile iron pipe and fittings shall have a standard epoxy prime coating per the section entitled “Painting and Coating” of these Specifications. All exposed ductile iron pipe and fittings shall have an outside coating per the section entitled “Painting and Coating” of these Specifications.
- B. All ductile iron pipe and fittings used for wastewater process shall have an interior lining of polybond, polyline, polyurethane or protecto 401 ceramic epoxy lined with a minimum thickness of 40 mils and sealed, as required, with an approved exterior coating per section 2.05 A. of this specification. All ductile iron pipe and fittings used for potable water or plant water shall have a standard cement interior lining in accordance with ANSI A21.40 (AWWA C104) and sealed with an approved bituminous seal coat in accordance with ANSI A21.51 (AWWA C151).
- C. No lining shall be provided for ductile iron pipe and ductile iron and cast iron fittings used for air. The exterior of the pipe and fittings shall be coated with a standard epoxy coating per the section entitled “Painting and Coating” of these Specifications.

2.06 PIPE COUPLINGS

- A. Pipe couplings shall be installed where shown on the Drawings, required for installation, or directed by the Engineer.

2.07 WALL PIPE AND WALL SLEEVES

- A. Contractor shall furnish and install cast iron wall pipe or wall sleeves where ductile iron piping connects with or passes through concrete walls or floors and in locations where small piping and electric wiring and conduits connect with or pass through concrete walls or floors.
- B. Where wall pipes or sleeves are to be installed flush with the wall or slab, the flange or bell shall be tapped for studs. Where the flange or bell will project beyond the wall, the projection shall be sufficient to allow for installation of connecting bolts.
- C. Where ductile iron piping passes through wall sleeves, grooved end joining method shall be exclusively used to make the interior connection. Usage of field assembled threaded-on flanges shall not be permitted.

PART 3 - EXECUTION

3.01 LAYING

- A. Proper and suitable tools and appliances for safe and convenient handling and laying of pipe and fittings shall be used. Great care shall be taken to prevent the pipe coating from being damaged, particularly cement linings on the inside of the pipes and fittings. Any damage shall be remedied as directed by the Engineer.
- B. All pipe and fittings shall be carefully examined by the Contractor for defects just before laying and no pipe or fitting shall be laid which is defective. If any defective pipe or fitting is discovered after having been laid, it shall be removed and replaced in a satisfactory manner with a sound pipe or fitting by the Contractor at his own expense.
- C. All pipes and fittings shall be thoroughly cleaned before they are laid and shall be kept clean

until they are used in the completed work. Open ends of pipe shall be kept plugged with a bulkhead during construction.

- D. Pipe laid in trenches shall be laid true to line and grade on a firm and even bearing for its full length at depths and grades as shown on the drawings. Adequate precautions shall be taken to prevent flotation of pipelines prior to backfilling. Installation of ductile iron pipe in underground pressure piping systems shall conform to the requirements of AWWA C600. Excavation of trenches and backfilling around pipes shall conform to requirements of the section entitled "Earthwork" of these Specifications.
- E. All ductile iron piping laid underground shall have a minimum of 42 inches of cover above the top of the pipe unless otherwise shown on the Drawings.
- F. All elbows, tees, branches, crosses, and reducers in pressure piping systems shall be adequately restrained against thrust. Underground pressure piping containing unharnessed push-on or mechanical joints or expansion joints shall be restrained by thrust blocks. Thrust blocks shall consist of Class B concrete conforming to requirements of the section entitled "Cast-In-Place Concrete" of these Specifications and shall be of the size and shape as shown on the Drawings. The Contractor may use forms or earth walls to mold the thrust blocks. When earth walls are used, they shall be cut true to shape and all excess earth removed. The work shall be conducted so that no loose earth will become mixed with the concrete. At the end of 24 hours, damp earth may be placed over the concrete to retain moisture.
- G. Wall pipe and wall sleeves shall be accurately located and securely fastened in place before concrete is poured. All wall pipe and wall sleeves shall have wall collars properly located to be in the center of the wall where the respective pipes are to be installed.
- H. Wall pipe and wall sleeves shall be installed when the wall or slab is constructed. Blocking out or breaking of the wall for later insertion shall not be permitted.
- I. Cutting or weakening of structural members to facilitate pipe installation shall not be permitted. All piping shall be installed in place without springing or forcing.
- J. Sufficient couplings and flanged joints shall be provided to facilitate equipment installation and removal.
- K. All ductile iron pipe installed under buildings or basins shall be encased in Class B concrete. The size of the encasement concrete shall be minimum of 6 inches larger than the outside diameter of the pipe.
- L. Grooved joints shall be provided to facilitate equipment installation and removal.
- M. Exposed ductile iron piping shall be supported as shown on the Drawings and specified in the section entitled "Hangers and Supports for Process Piping" of these Specifications.

3.02 CUTTING

- A. Whenever pipe requires cutting to fit the lines, the work shall be done in such a manner as to leave a smooth end at right angles to the axis of the pipe. When a piece of pipe is cut to fit into the line, no payment will be made for the portion cut off and not used.
- B. Whenever existing pipe requires cutting to install new fittings, the work shall be done in such a manner as to leave a smooth end at right angles to the axis of the pipe and special care shall be exercised to guard against breaking or splitting the existing piping.
- C. All cutting of ductile iron pipe shall be done with a cutting saw. All burrs shall be removed from the inside and outside edges of all cut pipe.

3.03 JOINING

A. Mechanical Joints

1. Successful operation of the mechanical joint specified requires that the spigo be centrally located in the bell and that adequate anchorage shall be provided where abrupt changes in direction and dead ends occur.
2. Surfaces with which the rubber gasket comes in contact shall be brushed thoroughly with a wire brush just prior to assembly to remove all loose rust or foreign material which may be present and to provide clean surfaces which shall be brushed with a liberal amount of soapy water or other approved lubricant just prior to slipping the gasket over the spigot end and into the bell. Lubricant shall be brushed over the gasket prior to installation to remove loose dirt and lubricate the gasket as it is forced into its retaining space.
3. Joint bolts shall be tightened by the use of approved wrenches and to a tension recommended by the pipe manufacturer. When tightening bolts, it is essential that the gland be brought up toward the pipe flange evenly, maintaining approximately the same distance between the gland and the face of the flange at all points around the socket. This may be done by partially tightening the bottom bolt first, then the top bolt, next the bolts at either side and last, the remaining bolts. This cycle shall be repeated until all bolts are within the range of acceptable torques. If effective sealing is not attained at the maximum torque indicated above, the joint shall be disassembled and reassembled after thorough cleaning. Overstressing of bolts to compensate for poor installation shall not be permitted.
4. After installation, bolts and nuts in buried piping shall be given 2 heavy coats of a bituminous paint.

B. Flanged Joints

1. All flanges shall be true and perpendicular to the axis of the pipe. Flanges shall be cleaned of all burrs, deformations, or other imperfections before joining. Flanged joints shall be installed so as to ensure uniform gasket compression. All bolting shall be pulled up to the specified torque by crossover sequence. Where screwed flanges are used, the finished pipe edge shall not extend beyond the face of the flange, and the flange neck shall completely cover the threaded portion of the pipe.
2. Connections to equipment shall be made in such a way that no strain is placed on the equipment flanges. Connecting flanges must be in proper position and alignment and no external force may be used to bring them together properly.
3. After installation, bolts and nuts in buried piping shall be given 2 heavy coats of a bituminous paint.

C. Push-On Joints

1. The inside of the bell and the outside of the pipe from the plain end to the guide stripe must be wiped clean immediately before assembling the pipe joint. Then the rubber gasket shall be inserted into a groove or shaped recess in the bell. Both the bell and spigot ends to be joined shall be wiped again to ensure they are thoroughly clean. A liberal coating of special lubricant furnished by the pipe manufacturer shall be applied to the outside of the pipe from the plain end to the yellow guide stripe and to the inside of the gasket. The plain end shall be centered in the bell and the spigot pushed home. Wherever possible the pipe shall be socketed by hand; however, jacking may be required to push the spigot in place on the larger sizes of pipe. The completed joint shall be permanently sealed and watertight.

2. Whenever the pipe is cut in the field, the cut end shall be conditioned so it can be used in making up a joint by filling or grinding the cut end to remove burrs or sharp edges that might damage the gasket.

D. Permissible Deflection of Joints

1. Deflection of ductile iron pipe at joints for long radius curves or for avoiding obstacles shall be permitted only upon approval of the Engineer.
2. Where deflection of joints is permitted, such deflection shall be made in accordance with and shall not exceed limits provided in Section 9b.5 and Section 9c.4 as applicable, of the AWWA C600.

E. Joints of Dissimilar Metals

When a flanged joint consists of a ductile iron flange mated to a steel or alloy flange, the steel flanges shall be flat faced and furnished with full-faced gaskets, insulating bushings, and stainless steel bolts.

F. Restrained Joints

1. Assembly of restrained joints varies depending on the type of joint used. Assembly shall be in strict accordance with joint manufacturer's recommendations.

3.04 SERVICE CONNECTIONS

- A. In general and unless otherwise shown, small service lines and branches shall connect to larger ductile iron mains using tapped tees and crosses.
- B. Tapped tees and crosses shall have minimum 2-inch NPT branch connections and shall be furnished with mechanical joint ends.

3.05 CUT-INS TO EXISTING PIPING

- A. In general, and unless otherwise shown, cut-ins to existing ductile iron piping for installation of new mechanical joint fittings and valves shall be made using ductile iron mechanical joint sleeves.
- B. Mechanical joint sleeves shall have a pressure rating not less than that of the existing pipeline and shall be furnished with a mechanical joint end on both ends.

3.06 DRILLING AND TAPPING

- A. Wherever required ductile iron pipe and fittings and cast iron fittings shall be drilled and tapped to receive drainage or any other piping. All holes shall be drilled accurately at right angles to the axis of any pipe or fitting. Where plugs are drilled, holes shall be at right angles to the face of the plug.
- B. Where the size of the pipe to be connected is such as to require bosses for connection and when the pipe wall thickness is too thin to permit the effective length of pipe threads to be utilized as necessary for the size pipe being connected by threads, the Contractor shall furnish such pipe with cast-on bosses suitable for drilling, tapping and connecting such pipe. Alternately, where shown or specified a tapped saddle clamp may be used in lieu of a cast-on boss. Saddle clamps shall be of the heavy-duty type with O-ring gasket and stainless steel straps.
- C. All tapping shall be carefully and neatly done by skilled workman with suitable tools.

- D. Where connections are made between new and old connections shall be made in a thorough and workmanlike manner using proper fittings and specials to suit actual conditions.
- E. Cut-ins to existing and operating pipelines shall be done at times agreeable to the Owner upon approval of the Engineer.
- F. Existing pipelines that may be cut or damaged during the performance of work under this item shall be repaired, reconnected and returned to service in equal or better condition in which they were found and in accordance with the requirements of this Specification.
- G. No separate payment will be made for drilling, tapping making connection, cut-ins, repairs to damaged existing pipelines and reconnections in existing pipelines.

3.07 FIELD TESTING

- A. After all piping has been placed and backfilled between the joints, each run of newly laid pipe, or any valved section thereof, shall be tested by the Contractor in the presence of the Engineer, and tests shall be continued until all leaks have been made tight to the satisfaction of the Engineer.
- B. All pressure piping shall be subjected to a hydrostatic gauge pressure of 175 psi based on the elevation of the lowest point of the section of pipe under test and corrected to the elevation of the test gauge. The above pressure shall be maintained for a minimum of 2 consecutive hours. Test pressure shall not vary by more ± 5 psi for the duration of the test.
- C. The Contractor shall take all precautions necessary to protect any equipment that might be damaged by pressures used in the tests. Delicate equipment shall be valved off, removed, or otherwise protected.
- D. All piping shall be securely anchored and restrained against movement prior to application of test pressures. Prior to the pressure test, pipe lain in trenches shall be partially backfilled adequately to secure the pipe during the test. All joints, fittings, and valves will be left open where possible. All exposed pipe, fittings, valves, and joints shall be carefully examined during the pressure test.
- E. Before applying the specified test pressure, all air shall be expelled from the pipe. If hydrants, blow-offs, or air release valves are not available at the high places, the Contractor shall make the necessary taps at point of highest elevation before the test is made and insert plugs after the test has been completed.
- F. After satisfactory completion of the pressure test, (all pressure piping) shall be leak tested. Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe or any valved section thereof to maintain pressure within 5 psi of the specified test pressure after the pipe has been filled with water and the air has been expelled. No pipe installation will be accepted if the leakage is greater than that determined by the following formula:

$$L = \frac{ND\sqrt{P}}{10,000}$$

L = Allowable Leakage in Gallons per hour

N = The Number of Joints in the section of pipe tested

D = The normal diameter of the pipe in inches

P = The average test pressure during the leakage test in psig

- G. Any leakage developing during the test in excess of the allowable leakage shall be corrected at

the Contractor's expense by tightening, replacing packing of gaskets, or replacing defective portions of the piping system. **Caulking will not be permitted.** If the defective portion cannot be located, the Contractor at his expense, shall remove and reconstruct as much of the original work as necessary to obtain a system without leakage.

- H. After all tests on any section have been completed to the satisfaction of the Engineer, the Contractor shall carefully clean, blow out, and drain the line of all water to prevent freezing. The Contractor shall also demonstrate to the satisfaction of the Engineer that any and all lines are free from obstructions and foreign material.
- I. The Contractor shall bear the complete cost of the tests, including set-up, labor, temporary piping, blocking, gauges, bulkheads, water, air, soap solutions, and other materials required to conduct the tests.**
- J. Inspection and testing of ductile iron pipe used for gravity sewer shall be carried out in accordance with procedures established in the section entitled "Polyvinyl Chloride (PVC) Sewer Pipe" of these Specifications.

END OF SECTION

SECTION 40 05 24
STEEL PROCESS PIPE

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install, complete ready for operation, field test all steel pipe and appurtenances as shown on the Drawings (including all steel pipe within buildings and structures) and as specified herein.
- B. Pipe for compressed air systems shall be seamless carbon steel (ASTM A53, Grade B).
- C. Pipe for plant water or potable water systems shall be galvanized steel (ASTM 153) unless noted otherwise.

1.02 RELATED WORK

- A. Section 40 05 52 Process Valves
- B. Section 09 90 0 Painting and Coating
- C. Section 40 05 07 Hangers and Supports for Process Piping
- D. Section 33 13 00 Disinfecting of Potable Water Lines

1.03 SHOP DRAWINGS AND ENGINEERING DATA

- A. Complete shop drawings and engineering data on all piping and accessories shall be submitted to the Engineer in accordance with requirements of the section entitled "Submittal Procedures" of these Specifications.

1.04 STORAGE AND PROTECTION

- A. Piping and accessories shall be stored and protected in accordance with requirements of the section entitled "Product Requirements" of these Specifications.

1.05 FIELD PAINTING

- A. Unless otherwise specified herein, all steel pipe and fittings shall be cleaned and painted in accordance with Section 09 90 00 of these Specifications.
- B. Galvanized steel pipe shall not be painted.**

PART 2 – PRODUCTS

2.01 STEEL PIPE

- A. Steel pipe in sizes 2 ½ inches and smaller shall be seamless carbon steel pipe conforming to the requirements of ASTM A120. Steel pipe in sizes 3 inches through 10 inches shall be seamless carbon steel pipe conforming to the requirements of ASTM A53, Grade B.
- B. Unless otherwise specified or shown, steel pipe 6 inches and smaller shall be screwed, Schedule 40. Steel pipe for process piping in sizes 3 inches through 6 inches shall be welded, Schedule 40. Steel pipe in sizes 8 inches through 10 inches shall be welded, Schedule 20 exposed, Schedule 40 buried.
 - 1. Screwed fittings 2½ inches and smaller shall be 150-pound malleable iron conforming to ASTM A197 and ANSI B16.3. Unions shall be 300-pound malleable iron.

2. Welded fittings shall be of the butt-welded type of wrought carbon steel conforming to ASTM A234, Grade WPB and ANSI B16.9. Reducing branch connections shall be made using threadolets or weldolets.
3. Flanges shall be 150-pound, forged steel conforming to ASTM A181, Grade 1, and ANSI B16.5. Bolts shall be ASTM A307, Grade B, zinc plated. Nuts shall be heavy hex nuts conforming to ASTM A307, Grade B, zinc plated. Gaskets shall be of red rubber 1/16-inch thick, conforming to ANSI B16.21. Gaskets for piping operating at temperatures in excess of 150° F shall be soft corrugated metal.
4. Unless otherwise shown or specified, steel pipe and fittings 6 inches and smaller in size shall be hot dip galvanized in accordance with the requirements of ASTM A153. Hot dipped galvanized pipe shall not be painted unless noted otherwise. Exposed carbon steel piping shall be field primed and painted in accordance with the requirements of the section entitled "Painting and Coating" of these Specifications.

2.02 EXPANSION COUPLINGS

- A. Expansion couplings shall be furnished where shown on the Drawings, required, or directed by the Engineer.

2.03 COATINGS

- A. Where shown or specified, buried piping shall be furnished with a coal tar enamel coating or cold-applied, plastic tape wrap coating as described herein.
- B. Coal tar enamel coatings shall consist of a primer, a hot-applied coating of coal tar enamel, a bonded wrap of coal tar saturated asbestos felt, and a protective wrapping of 75-pound Kraft paper. Pipe to be coated shall be given a solvent cleaning followed by a commercial blast cleaning in accordance with SSPC SP-6. Primer shall be applied immediately after blasting. Except for specials, fittings, and field joints, all pipe shall be coated in the shop by mechanical means. Coal tar enamel coatings shall conform to the requirements of AWWA C203.
- C. Cold-applied, plastic tape wrap coatings shall consist of a primer, a cold-applied wrap of laminated polyethylene tape, and a protective wrapping of 90-pound Kraft paper or 50-50-50 pound laminated Kraft Paper. Pipe to be coated shall have a solvent cleaning followed by a commercial blast cleaning in accordance with SSPC SP-6. Primer shall be applied immediately after blasting. Laminated tape wrap shall have an overall thickness of not less than 30 mils and shall overlap each preceding wrap by at least ½ inch. Except for specials, fittings, and field joints, all pipe shall be coated in the shop by mechanical means. Cold-applied plastic tape wrap coatings shall comply with the requirements of AWWA C209 and C214. Plastic tape coatings and materials shall be as manufactured by the Tapecoat Company, Republic Steel Corporation, Polyken Division of Kendall Company, or equal, subject, however, to the requirements of the Specifications.
- D. The manufacturers of the coated pipe and field coating materials shall provide the Engineer with written certifications that the pipe coating systems conform to all applicable requirements of AWWA C203, C209, C210, or C214m, as appropriate.

PART 3 - EXECUTION

3.01 GENERAL

- A. All exposed piping shall be firmly anchored and supported by pipe supports or anchors as shown on the Drawings or in accordance with requirements of the section entitled "Hangers and Supports for Process Piping" of these Specifications. All pipe shall be carefully placed to the

proper lines and grades as shown on the Drawings.

- B. Full lengths of pipe shall be used wherever possible. Short lengths of pipe with couplings will not be permitted. Pipe shall be cut to exact measurement and shall be installed without forcing or springing.
- C. Offsets, transitions, and changes in direction in pipes shall be made as required to maintain proper headroom, slope, etc.
- D. Piping shall be installed in such a manner and at such times as will require a minimum of cutting and repairing of building structures. In case any such cutting or repairing is necessary, it shall be done only with permission of the Engineer. Cutting and repairing shall be performed by craftsmen of the trade, which originally executed the work, and repairs shall match the original condition.
- E. A liberal number of unions and/or flanged joints shall be used to permit the ready removal of any section. Unions shall be installed in all piping connections to equipment, to regulating valves, and wherever necessary to facilitate the dismantling of pipeline and removal of valves and other items requiring maintenance. Flanges on equipment may be considered as unions.
- F. Installed piping shall not interfere with the operation of or accessibility to doors and/or windows, shall not encroach on aisles, passageways and equipment, and shall not interfere with the servicing or maintenance of any equipment.
- G. The interior of all piping shall be free from obstructions and protrusions. All burrs shall be removed from the inside and outside edges of all cut pipe by reaming. Cutting shall be done in such a manner so as to leave a smooth end at right angles to pipe threads. Tool marks and unnecessary pipe threads shall be avoided. Cuttings and other foreign material shall be removed from the inside of the pipe prior to installation.
- H. Unless otherwise shown on the Drawings, piping laid underground shall have a minimum cover over the top of the pipe as follows:
 - 1. Located in Roadway: 48 inches
 - 2. Located in Other Paved Areas: 36 inches
 - 3. Water, Gas, and Drain Piping,
 - a. 4-inch I.D. and larger: 30 inches
 - 4. Water, Gas, and Drain Piping,
 - a. 3 -inch I.D. and smaller: 24 inches
 - 5. Located under Building: 6 inches
- I. Suitable galvanized steel pipe sleeves of adequate inside diameter shall be provided where piping or tubing passes through walls and floors of buildings and structures. Inside diameter of sleeve shall be approximately ½-inch larger than outside diameter of pipe or insulation. A welded steel plate waterstop with a minimum dimension 4 inches larger than outside diameter of sleeve shall be furnished for use in underground walls. Sleeves shall be built into the concrete or masonry wall or floor. Under no circumstances will blocking out or breaking of walls be permitted for later insertion. After installation of piping, space between the pipe and the sleeve shall be caulked air and watertight.
- J. After installation, the interior of all piping shall be cleaned as necessary to remove flux, slag, scale, rust, dirt, oil, and other foreign material. As piping is installed, open ends shall be

covered or plugged as necessary to prevent the entrance of foreign matter and to maintain the required cleanliness.

- K. Piping laid underground shall be fully supported along its entire length by a compacted layer of select earth backfill or sand in accordance with requirements of the section entitled "Earthwork" of these Specifications. Select earth backfill (or sand, in the case of coated or wrapped steel pipe) shall also be placed and compacted around the piping to provide a cover of not less than 12 inches over the top of the pipe.
- L. Piping and tubing shall be supported as shown on the Drawings and/or specified in the section entitled "Pipe Supports and Hangers" of these Specifications.
- M. Changes in pipe size shall be made using reducing fittings, not brushings. If centerline elevation is not specified, use eccentric reducers in horizontal piping. On liquid lines, eccentricity shall be down with top of pipe level. On vapor and gas lines, eccentricity shall be up with bottom level.
- N. Indicated locations and sizes of equipment connections are approximate; exact locations and sizes of piping, valves, etc., shall conform to reviewed shop drawings. Connection sizes shall not be smaller than scheduled size or equipment outlet size, whichever is larger.

3.02 INSTALLATION OF STEEL PIPING

- A. Pipe threads shall be concentric with the outside of the pipe and shall conform to ANSI B2.1. When threading stainless steel pipe, dies shall have 20- to 30-degree hook. Finished joints shall have no more than 3 threads exposed. Before assembly, pipe ends and threads shall be inspected and any defective pieces replaced. All joints shall be properly aligned before connection to prevent thread damage. Pipe dope shall be used on the male threads of all threaded connections. Teflon thread tape shall be applied 2 threads back from the end of the pipe or fitting to prevent shredding. Excess pipe dope shall be trimmed or cleaned off to provide adherence for paints or coatings. After joining, exposed threads in underground piping shall be given a heavy coat of bituminous paint or other suitable protective compound prior to backfilling.
- B. All flanges shall be faced and drilled and shall be true and perpendicular to the axis of the pipe. Flanges shall be cleaned of all burrs, deformations, or other imperfections before joining. Flanged joints shall be installed so as to ensure uniform gasket compression. All bolting shall be pulled up to the specified torque by crossover sequence. Where screwed flanges are used, the pipe edge shall not extend beyond the face of the flange, and the flange neck shall completely cover the threaded portion of the pipe. Where slip-on flanges are used, the distance from the end of the pipe to the gasket face of the flange shall not exceed "t" plus 1/4-inch, where "t" is the pipe wall thickness. Unless otherwise required, boltholes shall straddle the vertical and horizontal axes of the pipe. Connection to the equipment shall be made in such a way that no strain is placed on the equipment flanges.
- C. For flanged connections between steel or alloy piping and castor ductile iron piping or valves, steel flanges shall be flat faced and furnished with full-face gaskets, insulating bushings, and, when buried, stainless steel bolts.
- D. Where steel pipe is connected to copper tubing, insulating bushings or couplings shall be used to prevent galvanic corrosion.

3.03 FIELD TESTING

- A. After all piping has been placed and backfilled between the joints, each run of newly laid pipe, or any valved section thereof, shall be tested by the Contractor in the presence of the Engineer,

and tests shall be continued until all leaks have been made tight to the satisfaction of the Engineer.

- B. All piping carrying liquids under pressure shall be subjected to a hydrostatic gauge pressure of 150 percent of the maximum expected operating pressure or 150 psig, whichever is greater, based on elevation of the lowest point of the section under test, corrected to the elevation of the pressure gauge. All piping carrying compressed air shall be subjected to a hydrostatic gauge pressure of at least 150 percent of the maximum expected operating pressure or 150 psig, whichever is greater. The above pressures shall be maintained for a minimum of 2 consecutive hours. No leakage will be allowed. Leakage may be determined by loss of pressure, soap solution, or other methods approved by the Engineer.
- C. Process piping, designed in accordance with ANSI B16.3 or ANSI B16.4, shall be tested in accordance with the requirements contained therein.
- D. The Contractor shall take all precautions necessary to protect any equipment that might be damaged by the pressures used in the tests. Delicate equipment shall be valved off, removed or otherwise protected.
- E. All piping shall be securely anchored and restrained against movement prior to application of test pressures. Prior to the pressure test, pipe laid in trenches shall be partially backfilled adequately to secure the pipe during the test. All joints, fittings and valves will be left open where possible. All exposed pipe, fittings, valves, and joints shall be carefully examined during the pressure test.
- F. Before applying the specified test pressure during a test using water as the pressurizing medium, all air shall be expelled from the pipe. If hydrants, blowoffs, or air release valves are not available at high places, the Contractor shall make the necessary taps at points of highest elevation before the test is made and insert plugs after the test has been completed.
- G. Subject welded joints to hammer tests while under pressure.
- H. Any leakage developing during the test shall be corrected at the Contractors expense by tightening, replacing packing or gaskets, or replacing defective portions of the piping system. No caulking will be permitted. If the defective portion cannot be located, the Contractor, at his expense, shall remove and reconstruct as much of the original work as necessary to obtain a piping system tested without leakage.
- I. After all tests on any section have been completed to the satisfaction of the Engineer, the Contractor shall carefully clean, blow out, and drain the line of all water to prevent freezing of the same. The Contractor shall also demonstrate to the satisfaction of the Engineer that any and all lines are free from obstruction and foreign material.
- J. The Contractor shall bear complete cost of the tests, including set up, labor, temporary piping, blocking, gauges, bulkheads, water, air, soap solutions, and other materials required to conduct the tests.

3.04 FIELD PAINTING

- A. Following installation and testing, all exposed piping shall be field primed and painted in accordance with requirements of the section entitled "Painting and Coating" of these Specifications.

3.05 DISINFECTION

- A. Following installation and testing, potable water lines shall be disinfected in accordance with

requirements of the section entitled "Disinfecting of Potable Water Lines" of these Specifications.

END OF SECTION

SECTION 40 05 52
PROCESS VALVES

PART 1 GENERAL

1.01 SCOPE

- A. Work covered by this section includes furnishing all labor, equipment, and materials required to furnish and install all metal valves, including operators, electric actuators, boxes, and accessories, as specified herein, shown on the Drawings, or required for proper completion of the work under these Contract Documents.
- B. The Contractor's attention is called to the fact that all valves, especially in the smaller sizes, are not necessarily shown completely on the Drawings, which are more or less schematic. However, the Contractor shall furnish and install all valves indicated or required for proper operation of the equipment or services requiring such valve.
- C. Polyvinyl chloride (PVC) valves shall be furnished under the section entitled "Polyvinyl Chloride (PVC) Pipe" of these Specifications.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 33 00: Submittals Procedures
- B. Section 01 60 00: Product Requirements
- C. Section 01 70 00: Execution and Closeout Requirements
- D. Division 40: Piping
- E. Section 09 90 00: Painting and Coating

1.03 SHOP DRAWINGS AND ENGINEERING DATA

- A. Complete shop drawings and engineering data on all piping and accessories shall be submitted to the Engineer in accordance with requirements of the section entitled "Submittal Procedures" of these Specifications.

1.04 STORAGE AND PROTECTION

- A. Valves and accessories shall be stored and protected in accordance with requirements of the section entitled "Product Requirements" of these Specifications.
- B. Valves shall be completely drained prior to shipment. Ends of flanged and mechanical joint valves shall be protected with full size wooden baffles securely bolted to the valve ends. Size of baffles shall be at least equal to outside diameter of flange. Valves 24-inches in size and larger shall be secured to a wooden skid to facilitate handling and storage.

1.05 PAINTING

- A. Unless otherwise specified, all interior and exterior nonmachined, nonbearing ferrous surfaces on iron body valves, and accessories for buried or submerged service shall be blast-cleaned and painted at the factory with 2 coats of asphaltic varnish conforming to Federal Specification TT-C-494A.
- B. Exterior nonmachined, nonbearing ferrous surfaces on valve operators and on exposed valves shall be blast-cleaned and painted at the factory with 1 coat of zinc chromate primer

conforming to Federal Specification TT-P-645A.

- C. The valve supplier, subject to the Engineer's approval, may propose other paint systems.
- D. All exposed valves shall be field primed and painted in accordance with the section entitled "Painting and Coating" of these Specifications.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit complete operation and maintenance data on the valves in accordance with requirements of Section 01 70 00 Operating and Maintenance Manual of these Specifications.

1.07 QUALITY ASSURANCE

- A. The valve manufacturers shall furnish a written certification to the Engineer that all valves and operators furnished comply with all applicable requirements of the governing AWWA standards specified herein.

1.08 GUARANTEE

- A. Provide a guarantee against defective equipment and workmanship in accordance with requirements of the section entitled "Execution and Closeout Requirements" of these Specifications.

PART 2 PRODUCTS

2.01 GENERAL

- A. All castings, regardless of material, shall be free from surface defects, swells, lumps, blisters, sand holes, or other imperfections.
- B. All valves shall have the name of the manufacturer, rated working pressure, and size of the valve cast upon the body or bonnet in raised letters. Alternately, the name of the valve manufacturer, rated working pressure, and size may be stamped on a stainless steel identification plate permanently attached to the valve body or bonnet. Valves specified to conform to AWWA requirements should have the letters "AWWA" cast upon the valve body or bonnet in raised letters.
- C. Valves and operating mechanisms shall be of the proper size and dimensions to fit the pipe connections thereto and shall be installed in the position and within the space shown on the Drawings.
- D. Unless otherwise specified, the direction of rotation of the operator to open the valve shall be to the left (counterclockwise). Each valve body or operator shall have cast thereon the word OPEN and an arrow indicating the direction to open.
- E. A union or coupling shall be provided within 2 feet on each side of a threaded end valve unless the valve can be otherwise easily removed from the piping. This shall not apply to soldered end valves in copper plumbing.
- F. All exposed bolts and nuts on buried or submerged valves and operators shall be brass or stainless steel for corrosion resistance. Exposed bolts and nuts on exposed valves and operators shall be of corrosion-resistant materials or shall be zinc plated.
- G. Valves and operators shall be of the proper size to fit the pipe connections and shall fit in the position and space as shown on the Drawings.
- H. Valve operators shall be of sufficient size and capacity to seat, unseat, and operate the valve under the maximum specified differential pressure. Where no maximum differential pressure is

specified, the operator shall be designed for a differential pressure equal to the maximum working pressure of the valve. Additional allowances shall be made for the lubricating and/or scale forming tendencies of the fluid.

- I. Valves and operators designed for buried service shall be provided in all underground applications.

2.02 GATE VALVES

- A. Unless otherwise specified, all gate valves shall be of the single disc, double-seated, solid tapered resilient wedge type. Valves shall have non-rising stems and shall be capable of being repacked under pressure when valve is fully open. Iron body gate valves for potable water lines shall be provided in all underground applications.
- B. Gate valves 2 ½ inches in size and smaller shall be bronze body, bronze-fitted valves, and shall have 150-pound, cast bronze body, union bonnet, Teflon-impregnated asbestos packing, and threaded ends per ANSI B2.1. Bronze shall conform to ASTM B 62. Brass for nuts and gland shall conform to ASTM B 16. Valve discs shall be reversible. For use in copper plumbing, gate valves shall be furnished with solder ends per ANSI B16.18.
- C. Gate valves 2 inches in size and larger in water and wastewater shall be iron body and body seat rings shall be ASTM B 62 bronze and shall be screwed into the body so as to be field replaceable. Valves conforming in all respects to the applicable material and dimensional requirements of AWWA C509. Minimum working pressures shall be 200 psi for valves 12 inches in size and smaller and 150 psi for valves 16 inches and larger. Gate valves shall have a triple O-ring stem seal. Two rings are located above and one O-ring below the thrust collar, O-rings set in a cartridge shall not be allowed and 125-pound flanged ends per ANSI B16.1, except for valves to be buried underground, which shall have mechanical joint ends per ANSI A21.11 (AWWA C111). Body seat rings shall be ASTM B 62 bronze and shall be screwed into the body so as to be field replaceable. Wedge shall be constructed of ductile iron and encapsulated in rubber. Cast iron for body and bonnet shall conform to ASTM A 126, Grade B. Iron body gate valves with solid resilient wedge discs shall be M&H, Mueller, American Darling or engineer approved equal.
- D. Gate valves 2 inches in size and larger in steam service shall have 125-pound cast iron body, bronze trim, and outside stem and yoke.
- E. Gate valves shall be furnished with nut, wrench, chain, or handwheel operators as shown on the Drawings. Unless otherwise shown or specified, valves shall have operators as specified herein. Extension stems, floorstands, and valve boxes and covers shall be furnished where shown or required.

2.03 GLOBE AND ANGLE VALVES

- A. Unless otherwise shown or specified, globe valves with straight-through pattern globe bodies shall be furnished. The direction shall be "flow opening." Globe and angle valve stems, seats, and seat rings shall be accessible and replaceable without removing the valve from the piping system. Valves shall be capable of being repacked under pressure when the valve is fully open.
- B. Valves sized 2 ½ inches and smaller shall be bronze-body and bronze mounted. Valves shall have 150-pound, cast bronze-body, union bonnet, Teflon-impregnated asbestos packing, and threaded ends per ANSI B2.1. Bronze for body and bonnet shall conform to ASTM B62. Valves for shutoff applications shall have a renewable disc, Buna-N for water or gas, Teflon for steam. Valves for throttling applications shall have a stainless steel plug-type disc hardened to at least 350 Brinnell and renewable stainless steel seat ring. Bronze globe valves shall be

Stockham Fig. B-22 or B-29, Jenkins Fig. 106 or 546, Nibco Fig T-235, or equal. Bronze angle valves shall be Stockham Fig. B-222 or B-229, Nibco Fig. 335, or equal. Valves used in copper plumbing shall have solder ends per ANSI B16.18.

- C. Valves sized 3 inches and larger shall be iron body, bronze mounted valves. Valves shall have 125-pound, cast iron body, bolted bonnet, outside stem and yoke, Teflon-impregnated asbestos packing, and 125-pound, flanged ends per ANSI B16.1. Cast iron for body and bonnet shall conform to ASTM A 126, Grade B. Bronze for trim shall conform to ASTM B 62. Valves for shutoff applications shall have renewable disc, Buna-N for water or gas, Teflon for steam. Valves for throttling applications shall have bronze disc and renewable bronze seat ring. Packing gland bolts shall be bronze with brass nuts.
- D. Valves shall be furnished with operating nut, wrench, or handwheel operator as shown on the Drawings. Unless otherwise shown or specified, valves shall be furnished with operators as specified herein.
- E. Where used as a stop and waste valve, globe valve shall be furnished with a 1/8-inch drain cap on downstream portion of body.

2.04 BUTTERFLY VALVES

- A. Unless otherwise shown or specified, butterfly valves shall be of the resilient seated, tight-closing type and shall conform in all respects to the applicable material and dimensional requirements of AWWA C504. Wafer-type butterfly valves in sizes 24 inches and larger shall conform to all general requirements of AWWA C504 except laying length. Butterfly valves shall operate from fully open to fully closed with a 90-degree rotation of the valve stem.
- B. Valves shall be designed for the working pressures and/or pressure class designations shown on the drawings or specified in these Specifications. If a working pressure or pressure rating is not given, the following requirements shall apply:

<u>Service</u>	<u>AWWA Pressure Rating</u>
Low Pressure Air	25 psi – 16 fps
Wastewater of Sludge	150 psi – 16 fps
Potable or Plant Water	150 psi – 16 fps

- C. Wafer-type valves shall have a pressure rating of not less than 150 psi. Valves shall be drip-tight and bubble-tight at rated pressure differential across the valve in both directions
- D. Valve body shall be 1-piece, constructed of cast iron conforming to ASTM A126, Class B. Diameter of the opening shall be not less than the diameter of the corresponding pipe size. Unless otherwise specified, valve body shall be of the short-body style in accordance with Table 3 of AWWA C504. This requirement shall not apply to wafer-type valves. No part of the valve internals shall extend beyond the valve ends when the valve is in the closed position. Short-body valves shall have 125-pound flanged ends per ANSI B16.1. Wafer-style valves shall be designed to fit between 125-pound flanges per ANSI B16.1.
- E. Disc shall be cast bronze conforming to ASTM B 143, Alloy 1A, cast iron conforming to ASTM A48, Class 40, Ni-resist ductile iron conforming to ASTM A 439, Type D2. When used in wastewater or raw water, disc shall be streamlined with no exterior ribbing or openings.
- F. Shafts shall be polished stainless steel conforming to ASTM A276, Type 304 or Type 316. All keys and pins used in securing valve disc to shafts shall be stainless steel or Monel.

- G. Valve seat shall be of 1-piece, molded synthetic rubber, Buna-N (Hycar) for wastewater and Buna-N or neoprene for air. Where temperatures exceed 180 degrees F, EPDM or Viton seats shall be used. Retaining rings, if used, shall be stainless steel. The method of mounting valve seat shall conform to applicable requirements of AWWA C504, Section 3.5. Valve seats in sizes 24 inches and larger shall be field replaceable without necessity of shipping, burning, or cutting. Seats secured with retaining rings shall be fully adjustable. Metal seat mating surfaces shall be smoothly contoured and polished 18-8 stainless steel or Monel. Alloy cast iron will not be acceptable as a seat-mating surface. Sprayed or plated seat mating surfaces will not be acceptable.
- H. Shaft seals shall be O-ring or self-adjusting chevron packing of Buna-N or neoprene. Shaft seals shall conform to the requirements of AWWA C504, Section 3.7, and shall be of a design that allows replacement of the seal without removing the valve shaft. Alternately, pull-down packing is acceptable if the packing is adjustable and replaceable without removing valve operator.
- I. Valve bearings shall be self-lubricating, sleeve-type bearings of corrosion resistant materials. Bearing load shall not exceed 2,500 psi. Valves 24 inches in size and larger shall be provided with an adjustable, 2-way thrust bearing to center the disc in the valve and allow the valve to be installed with the valve stem vertical. Bearing shall be easily accessible for adjustment.
- J. Where the valve is installed, adjacent to a fitting, flow meter, another valve, or similar items, a spool piece or adaptor coupling shall be furnished as a spacer so that valve disc does not interfere with operation of the adjacent meter or valve or contact cement linings on pipe or fittings.
- K. Valve shall be furnished with a lever operator, rotary manual operator, electric motor operator, or pneumatic cylinder operator as shown on the Drawings. Unless otherwise shown of specified, a lever operator shall be furnished on valves 6 inches and smaller, and a rotary manual operator shall be furnished on valves 8 inches and larger. Extension stem and floorstand shall be furnished, where shown or required.
- L. Butterfly valves shall be as manufactured by DeZurik or equal.

2.05 TWO-WAY PLUG VALVES

- A. Unless otherwise shown or specified, 2-way plug valves shall be of the eccentric, non-lubricated type with resilient, neoprene or nitrile-faced plugs providing drip-tight shut-off at rated pressure. Port area shall not be less than 80 percent of the corresponding full pipe area in sizes 16 inches and smaller and 100 percent of the corresponding full pipe area in valves 20 inches and larger. Two-way valves shall operate from fully open to fully closed with a 90-degree rotation of the valve stem.
- B. Valves shall be designed for a working pressure of not less than 175 psi in sizes through 16 inches and 150 psi in sizes 18 inches and larger. Valves shall be drip-tight at rated pressure differential in both directions.
- C. Valves shall have bodies of ASTM A 126, Grade B or ASTM A 48, Grade 40 cast iron. Valves 4 inches and larger in size shall have bolted bonnet.
- D. Body seats for resilient-faced plugs shall be welded in and shall contain a minimum of 90 percent nickel. Welded-in seats shall conform to applicable requirements of AWWA C507, Section 7.2 and AWWA C504, Section 9.4. Plugs shall have a field replaceable, full-circle rubber seat securely attached to the plug.

- E. As an equal to Paragraph D above, the nickel seat ring shall be fused into the plug and the field replaceable, full-circle rubber seat shall be located in the body.
- F. Shaft seal shall be of the self-adjusting or split-V type of Buna-N and shall comply with applicable requirements of AWWA C504, Section 11 and AWWA C507, Section 10. Seals requiring adjustment shall be adjustable and replaceable without bonnet or shaft removal.
- G. Bearings shall be supplied in both the upper and lower journals. Bearings shall be permanently lubricated and replaceable with stainless steel, bronze, or corrosion-resistant sleeves and bushings. Bearings shall conform to the applicable requirements of AWWA C504, Section 9 and AWWA C507, Section 8.
- H. Valves sized 2½ inches and smaller shall have threaded ends per ANSI B2.1. End connections for valves sized 3 inches and larger shall be 125-pound flanged per ANSI B16 or grooved-end per AWWA C606, except for valves to be buried underground, which shall have mechanical joint ends per ANSI A21.11 (AWWA C111). Flanged end valves in sizes 12 inches and smaller shall have a laying length equal to that of an AWWA gate valve of the same size.
- I. Valves intended for buried or submerged service shall be sealed against the entrance of water and dirt.
- J. Valves shall be furnished with a lever operator, rotary manual operator, or electric motor operator as shown on the Drawings. Unless otherwise shown or specified, a lever operator shall be furnished on valves 8 inches and smaller, and a rotary manual operator with handwheel shall be furnished on valves 10 inches and larger. Extension stem, floorstand, and valve box shall be furnished where shown or required.
- K. Two-way plug valves shall be manufactured by DeZurik or equal.

2.06 BALL VALVES - SMALLER THAN 6"

- A. Ball valves shall be of the quarter-turn type with full pipe size opening through the valve. Ball valves shall be suitable for a differential working pressure in either direction of not less than 400 psi.
- B. Ball valves shall have a 3-piece, bolted body designed to allow the interior portion of the valve to be removed without disturbing adjacent piping.
- C. Unless otherwise specified or required, ball valves shall have brass body, self-aligning brass ball, blowout-proof brass stem, reinforced Teflon seats and seals, plastic-coated plated steel handle, and threaded ends per ANSI B2.1. Ball valves shall be Powell "Star", Worcester "Miser", or equal.
- D. Ball valves shall be available with Type 316 stainless steel construction where shown or specified.

2.07 BALL VALVES – 6 INCHES AND LARGER

- A. Valves shall be quarter-turn, full-bore style rated for a minimum operating pressure of 150 psig.
- B. The valve body shall have integral support legs or pads and consist of 2 end pieces and a center body piece, through-bolted and O-ring-sealed against leakage. The center body casting shall house the bearings and be constructed of cast iron ASTM A126, Class B or A48, Class 35. End pieces shall be cast iron ASTM A126, Class B or A48, Class 35. Minimum body shell thickness shall be in accordance with AWWA C507 and flanges shall be drilled in accordance with ANSI B 16.1 for either Class 125 or Class 250 flanges.

- C. Ball shall be spherically shaped, of cast iron ASTM A48, Class 40, with a full line-size circular waterway in one direction, and at 90-degree position, provide drop-tight sealing. Head loss shall be the same as an equal length of straight pipe.
- D. Self-lubricating sleeve-type bearing shall be used in both trunnions of the valve body. Bearings shall support the shaft and provide minimum friction during shaft rotation. Bearing load shall not exceed 2000 psi. Bearing material shall be Teflon-lined with non-metallic backing or cast bronze complying with ASTM B584, AL 92300. Two-way thrust bearing shall be factory preset and consist of a stainless steel stud fastened to the bottom of the valve shaft. Stud shall extend beyond the bottom cover. The thrust collar shall be threaded to the stud and pinned. Bottom cover cap shall bolt to the bottom cover and retain the thrust collar, which, in turn, shall retain position of the assembly. The cavity, which contains the thrust collar, shall be packed with grease providing lifetime lubrication of thrust bearing assembly. Cap shall be fully gasketed to prevent leakage.
- E. An O-ring bearing seal shall be provided to exclude foreign matter from the bearing internals.
- F. The shafts shall be turned, ground and polished ASTM A-276 18-8 type 304 or type 316 stainless steel or AISI 4140 with hard chrome plating through the seal area. Shaft shall be sized to meet the maximum design condition of flow and pressure.
 - 1. Large stainless steel 18-8 type 304 or Monel taper pins threaded at one end and secured with lock washers and nuts shall be used to attach shaft to the ball.
- G. Seat shall have a multi-ridge surface of Buna-N providing a full 360-degree seal against a stainless-steel spherical surface on the ball. Seat shall be retained by a specially formulated casting epoxy compound designed to maintain the seat in uniform contact with the stainless seating surface on the ball when in the closed position. The seat shall be fully adjustable and replaceable in the field. As an alternate, the ball seat shall be ASTM A296 CF8 stainless steel with a flexible outer rim and a 2-degree offset to the bore axis. Metal seats, if used, shall screw onto the ball and be locked in place.
- H. Seating arrangement shall provide drop-tight seal when in the closed position.
- I. Ball shall have a corrosion-resistant, stainless steel spherical seating surface mating with rubber or Monel seat in the body end-piece.
 - 1. Valves shall be double-seated.
- J. Packing shall be self-adjusting "V" type located in trunnions of valve body where the shaft protrudes for operator connection. It shall be readily accessible without having to dismantle the valve.
- K. Ball valves shall be as manufactured by Pratt, or equal.

2.08 CHECK VALVES

- A. Unless otherwise shown or specified, check valves shall be of the swing type suitable for use in either horizontal or vertical piping. Disc shall swing entirely clear of the path of flow when in the open position. All internal parts shall be readily accessible and easily replaced in the field.
- B. Check valves in sizes 2 ½ inches and smaller shall be Y-pattern, regrinding, bronze-body, bronze-mounted valves. Valves shall have 200-pound, cast bronze body, renewable bronze disc, screwed cap, and threaded ends per ANSI B2.1. Bronze for body and cap shall conform to ASTM B16. Valves shall have a hinge bumper capable of preventing the valve from

sticking in the open position and an arrow cast on the valve body to indicate direction of flow. Bronze check valves shall be Powell Fig. 560Y, Stockham Fig. B-345, Nibco Fig. T453-B, or equal.

- C. Check valves in sized 3 inches and larger shall be iron body, bronze-mounted valves conforming to AWWA C508. Valves shall have 125-pound cast iron body, bolted and gasketed cover, stainless steel or brass hinge pin, renewable bronze seats and disc, outside lever and adjustable weight, and 125-pound flanged ends per ANSI B16.1. The lever arm and weight(s) shall be designed to meet the requirements of this Contract. Cast iron for body and cap shall conform to ASTM A 126, Grade B. Bronze for disc and seats shall conform to ASTM B 62. Iron body check valves shall be Mueller Fig. 2600-6-01, M & H (Dresser) Fig. 50, Nibco Fig. F-918-BL&W, or equal.
- D. Air-Cushioned Swing Check Valve
 1. The valve shall have a heavy duty body shall be constructed of high-strength cast iron conforming to ASTM A126 Class B with integral flanges, faced and drilled per ANSI B16.1 Class 125 and be suitable for horizontal or vertical installation.
 2. The valve body shall be the full waterway type, designed to provide a net flow area not less than the nominal inlet pipe size when swung open no more than 25 degrees. The valve shall have a replaceable bronze body seat.
 3. Valve disc shall be cast iron and faced with a renewable resilient seat ring of rubber or other suitable material, held in place by a follower ring and stainless steel screws.
 4. The disc arm shall be ductile iron or steel, suspended from and keyed to an austenitic stainless steel shaft which is completely above the waterway and supported at each end by heavy bronze bushings. The shaft shall rotate freely without the need for external lubrication. The shaft shall be sealed where it passes through the body by means of a stuffing box and adjustable packing. Simple O-ring shaft seals are not acceptable.
 5. The valve shall be supplied with an outside lever and adjustable counterweight to initiate valve closure. Final closure shall be dampened by means of a single, side-mounted bronze air-cushion assembly directly mounted to the valve body on machine pads. The amount of cushioning shall be easily adjustable without the need for pre-charged air chambers. Commercial air cylinders which pivot and/or are attached with fabricated brackets are not acceptable.
 6. The valve shall swing open smoothly at pump start and close quickly and quietly upon pump shutdown to prevent flow reversal. When closed, the valve shall seat drop tight.
 7. Manufacturer shall be GA Industries or engineer approved equal.
- E. Oil Controlled Closing Swing Check Valve
 1. The valve shall have a heavy duty body of high-strength cast iron conforming to ASTM A126 Class B with integral flanges, faced and drilled per ANSI B16.1 Class 125 for horizontal installation.
 2. Disc arm shall be fabricated of high strength steel and be suspended from and keyed to an 18-8 stainless steel shaft completely above the waterway and supported at each end by heavy bronze bushings. Shaft shall rotate freely without the need for external lubrication. Valve disc shall be faced with a renewable, resilient seat ring held in place by a follower ring and stainless steel screws, and shall seal tightly against a bronze replaceable body seat.

3. Shaft shall be sealed where it passes through the body by means of low friction pressure activated TFE v-rings or adjustable pack. Simple O-ring type shaft seals are not acceptable. An single external lever with adjustable counterweight shall be keyed to the shaft.
 4. Valve design shall provide for two speed closure. Rapid initial closure shall be effected by the outside counterweight. Final closure shall be controlled under full differential pressure across the open valve disc by means of a single, external side-mounted hydraulic cylinder. Final closure speed shall be easily adjusted by a needle type valve controlling the flow of hydraulic oil to and from an unpressurized reservoir. The point of transition from rapid initial to controlled final closure also shall be adjustable. The hydraulic cylinder shall be rigidly mounted to the valve body on machined pads using dowel pins or shoulder bolts to prevent fretting. Dual, bottom-mounted or pivoting hydraulic cylinders or pre-charged air chambers are not acceptable.
 5. The valve shall swing open smoothly at pump start and provide two-stage closing upon pump shutdown. Valve shall close quickly through the initial portion of closure and at a controlled rate of speed for the final pre-determined portion of its closing stroke to minimize surges associated with pump shut down by allowing a nominal amount of backflow through the valve during closing.
 6. Manufactures shall be G-A Industries, Inc. or engineer approved equal.
- F. Check valves in air or gas piping sized 2 ½ inches or smaller shall be bronze, swing type check valves conforming to the requirements of paragraph B above, except that the disc shall have a replaceable, resilient seat of Buna-N or Teflon. Bronze check valves for air or gas service shall be Nibco Fig., T-453-W, Kennedy Fig. 442, or equal.
 - G. Check valves in air or gas piping sized 3 inches and larger shall be of the double-plate, spring-loaded, clapper type with cast iron body, aluminum bronze or bronze plates, stainless steel hinge pin and springs, and Buna-N seats. When operating temperatures exceed 180 degrees F, Viton seats shall be used. Check valves shall be wafer-style bodies suitable for mounting between two 125-pound ANSI B16.1 flanges. Check valves shall be rated for a working pressure of not less than 150 psi. Clapper style check valves shall be Mission "Duo-Check," FMC, or equal. Clapper style check valves in horizontal piping shall be installed with the pin in a vertical position.

2.09 FLAPPER CHECK VALVES

- A. The Check Valve shall be of the full body flanged type, with a domed access cover and only one moving part, the flexible disc.
- B. Valves shall be provided with flanges in accordance with ANSI B16.1, Class 125.
- C. The valve body shall have full flow equal to nominal pipe diameter at all points through the valve. The seating surface shall be on a 45 degree angle to minimize disc travel. A threaded port with pipe plug shall be provided on the bottom of the valve.
- D. The top access port shall be full size, allowing removal of the disc without removing the valve from the line. The access cover shall be domed in shape to provide flushing action over the disc for operation in lines containing high solids content.
- E. The disc shall be of one-piece construction, precision molded with an integral O-ring type sealing surface, and contain steel and nylon reinforcement in the hinge. The flex portion of the disc shall be warranted for twenty-five years. Non-Slam closing characteristics shall be

provided through a short 35 degree disc stroke and a memory disc return action.

- F. The valve shall be cycle tested 1,000,000 times with no signs of wear or distortion to the valve disc or seat and shall remain drop tight at both high and low pressures. The test results shall be independently certified
- G. The valve body shall be constructed of ASTM A126 Class B cast iron.
- H. The disc shall be precision molded Buna-N (NBR), ASTM D2000-BG.
- I. Acceptable manufactures are Val-Matic Valve & Manufacturing, Golden-Anderson Industries, Inc., or engineer approved equal.

2.10 GLOBE (FLANGED) SILENT CHECK VALVES

- A. Silent check valves shall have ASTM A126 Class B cast iron body with integral flanged ends faced and drilled to ANSI B16.1 Class 125. Flow area through the valve shall be no less than the nominal valve size.
- B. Construction of 12in. and smaller globe style valve shall have concave, double-guided plug and seat of ASTM B62 bronze with stainless steel internal spring and a renewable resilient Buna-N seat retained in a dovetail groove with a metal-to-metal backup. Larger valves shall have double-guided cast iron Buna-N rubber faced disc, a bronze seat and a stainless steel stem with bronze bushings.
- C. The internal spring shall assist closure by exerting a force equivalent to ½ PSI and to close without slam under all closure conditions to positively prevent the return of water when the inlet pressure decreases below the outlet pressure.
- D. The valve shall be designed to open when the inlet pressure exceeds the outlet pressure by ½ PSI and to close without slam under all closure conditions to positively prevent the return of water when the inlet pressure decreases below the outlet pressure.
- E. Manufactures shall be GA Industries, Inc., Val-Matic or engineer approved equal.

2.11 SOLENOID VALVES

- A. Solenoid valves shall be packless piston type direct acting for sizes less than 1-in and internal pilot operated for sizes 1-in and larger, 2-way or 3-way, valves and shall be APCO Valve; GA Industries, Cla-Val, Red Hat as manufactured by Automatic Switch Co., equal by Atkomatic Valve Co. or equal for air and water service.
- B. Valves shall be energized to open, except for valves on water seal lines to pumps which shall be energize to close.
- C. Valves shall have forged brass bodies, NPT end connections of the connected piping Type 316 series stainless steel internal parts, and Buna-N or Ethylene Propylene valve seats. Valves shall have a minimum 150 psig safe working pressure and zero minimum operating pressure differential. Connections shall be threaded.
 - 1. Except as otherwise specified herein, valves shall be as noted in PART 1 of this Specification.
- D. Solenoid valves on bypass piping shall be installed whether shown or not.
- E. Note that solenoid valves may be shown on Electrical and/or Mechanical Drawings, or may only be specified.

- F. Solenoid valves shall be suitable for operation on a 120-volt, single phase, 60 Hertz power supply unless otherwise shown on the Drawings. Valves shall be provided in a Type 4X stainless steel, watertight enclosure. NEMA 7 enclosures shall be provided for hazardous locations.

2.12 HOSE BIBBS

- A. Hose bibbs shall be brass, polished chromium plated, as manufactured by Chicago Faucet Co. or equal. Potable water hose bibbs for wall mounting shall be No. G52, 3/4-in with vacuum breaker, equal by Nibco, Purtecor Sill Cocks Model 763VB with built-in vacuum breaker, or equal.

2.13 HOSE VALVES

- A. Hose end valves shall be globe pattern valves, equal to Fairbanks Fig. 074; Jenkins Fig. 112 or equal. Furnish cap and chain.

2.14 PRESSURE REDUCING VALVES FOR WATER

- A. Pressure reducing valves shall automatically reduce a higher inlet pressure to a preset, steady outlet pressure. The reducing valve shall be very sensitive to slight pressure changes and immediately control the main valve to maintain the desired pressure. Valve outlet pressure shall be adjustable between 3 and 30 psi.
- B. The main valve shall be direct acting, single-seated, spring-loaded, diaphragm-actuated, globe-type valve. When the downstream pressure exceeds the pressure setting, the main valve shall close drip-tight. Main valve shall be guided at 2 locations. No external packing glands shall be used and the diaphragm shall not be used as a seating surface.
- C. Pressure reducing valves sized 2 inches and smaller shall have cast bronze body, stainless steel seat ring, Teflon, Buna-N, or composition disc and diaphragm, and outside screw adjustment. Valves shall be suitable for 230 psi inlet pressure. Valves shall be furnished with threaded ends per ANSI B2.1.
- D. Pressure reducing valves 2 1/2 inches and larger shall have cast iron body, bronze trim, bolted cover, and pilot-controlled main valve. The pilot control system shall be external, connected to the valve with union fittings. Pressure setting shall be adjustable by a single screw adjustment enclosed in a tamperproof housing. Valve shall be suitable for an inlet pressure of not less than 175 psi. Valves sized 2 1/2 inches shall have threaded ends per ANSI B2.1. Valves 3 inches and larger shall have 125-pound, flanged ends per ANSI B16.1. Valve body and cover shall be of cast iron conforming to ASTM A 48. Valve trim and pilot control shall be of ASTM B 61 or B 62 bronze. Pilot control trim shall be stainless steel. Valve shall be supplied with an integral strainer, constructed of heavy and fine mesh monel screens, to protect the pilot control system from foreign particles. Pilot controlled valves shall be Clayton Fig. 90G-01, Golden Anderson Fig. 45-D, or equal.
- E. A separate Y-pattern strainer with threaded or bolted cleanout shall be furnished and installed immediately upstream of each pressure reducing valve. Area through the screen shall be not less than 4 times the full pipe area. Strainers shall have a pressure rating not less than that of the protected pressure-regulating valve.
- F. A 2-inch pressure gauge with tee-head, bronze gauge cock shall be installed on the upstream and downstream side of each pressure regulating valve unit. Pressure gauges on the upstream side shall have a range of approximately 0 to 160 psi. Pressure gauges on the downstream side shall have a range of approximately 0 to 80 psi.

2.15 NEEDLE VALVES

- A. Needle valves shall be of all bronze construction and shall have a seat opening of not less than $\frac{1}{4}$ inch. Valves shall be furnished with 200-pound bronze body, bronze stem, Teflon-impregnated asbestos packing, and threaded ends per ANSI B2.1. Bronze for body shall conform to ASTM B 61. Needle valves shall be Stockham Fig. B-64, Jenkins Fig. 741-G, or equal.

2.16 AIR RELEASE VALVES

- A. Air release valves shall have cast iron body, stainless steel float, and stainless steel or bronze trim.
- B. Valve shall be designed for a working pressure of 0 to 150 psi and shall be equipped with an orifice appropriate to the venting needs of the pipeline.
- C. Sewage valves shall be equipped with an elongated body, a 2-inch NPT inlet connection, and a $\frac{1}{2}$ -inch NPT outlet connection and shall be provided with 2-inch inlet shut-off valve, 1-inch blow-off valve, and $\frac{1}{2}$ -inch back-flush valve with quick-disconnect coupling and flushing hose with quick-disconnect connections.
- D. Sewage valves shall be manufactured by G-A Industries, Crispin or Val-Matic.

2.17 COMBINATION AIR RELEASE/AIR VACUUM VALVE

- A. Combination air valves shall be of the single-housing style that combines the operation features of both an air vacuum and air release valve.
- B. The air/vacuum portion shall automatically exhaust large quantities of air during the filling of the pipeline and automatically allow air to re-enter the pipeline during draining or when negative pressure occurs.
- C. The air release portion shall automatically release small pockets of air from the pipeline while the pipeline is in operation and under pressure.
- D. Combination air release valves shall be sized as shown on the Drawings. They shall be suitable for a maximum working pressure of 300 psi unless noted otherwise. Valves shall be manufactured by G-A Industries, Crispin, or Val-Matic.

2.18 SEWAGE SURGE RELIEF VALVE

- A. Main valve body shall be long radius elbow pattern of cast iron conforming to ASTM A126 Class B, with integral flanges, faced and drilled per ANSI B16.1 Class 125. The valve body shall be inherently self-cleaning and have a net flow area through the valve no less than the area of its nominal pipe size. The body shall have a removable bronze seat.
- B. The valve disc shall be cast iron or steel with a renewable, resilient seat ring of rubber or other suitable material and retained by a bronze or stainless steel follower ring and stainless steel screws. The valve stem shall be stainless steel bushing retained in the valve cover. The valve stem shall be sealed where it passes through the body by dual seals separated by a lantern ring external leak detection port.
- C. Sizes through 8" shall have dual compression springs; larger valves shall have a single compression spring. Springs shall be encased in steel cylinders; exposed springs or tension springs are not acceptable. An integral hydraulic system shall permit quick opening and adjustable slow closing without the need of pre-charged cylinders. The valve shall be fully capable of operating in any position.

- D. The valve shall be factory tested and set to open at a pre-determined pressure. Springs shall permit field adjustment from near zero to 10 percent above factory setting.
- E. The surge relief valve shall quickly open when the system pressure exceeds its setting, remain open as long as the pressure exceeds this setting, and slowly close drop tight when the pressure subsides below the spring setting.
- F. Manufactures shall be GA Industries, Inc. or engineer approved equal.

2.19 PRESSURE RELIEF VALVES FOR WATER

- A. Pressure relief valves for cold water in sizes 1 ½ inches and smaller shall be direct acting, single seated, spring loaded, diaphragm operated, globe type. Valve shall have bronze body, stainless steel trim, resilient disc, stainless steel, Monel, or bronze diaphragm and outside, tamperproof screw adjustment. Valve shall be suitable for 200 psi working pressure. Valve shall have NPT threaded ends per ANSI B2.1. Valve shall have no external packing glands. Seat, disc, and diaphragm shall be removable.
- B. Pressure relief valves for water in sizes 2 inches and larger shall be of the hydraulically operated, pilot actuated, diaphragm type globe or angle valves designed to relieve excessive pressure, sustain a constant back pressure, and prevent surges. The valve shall be fast opening and slow closing and shall be cushioned to prevent water hammer. Speed of opening and closing shall be adjustable. Valve shall be suitable for 175 psi working pressure. Setpoints shall be externally adjustable by means of tamperproof screw adjustment.
- C. The valve shall have a cast iron body and bolted bonnet conforming to ASTM A126, Class B, or ASTM A 48, Class 30, bronze pilot and main valve trim, resilient seat disc, stainless steel pilot trim, and reinforced synthetic rubber diaphragm. Seat ring, disc, and diaphragm shall be removable without removing valve from line. No external packing glands shall be used and the diaphragm shall not be used as a seating surface. Valve stem shall be guided at both ends. Pilot control shall be of the diaphragm actuated, spring-loaded type.
- D. A fine mesh stainless steel or Monel strainer shall be provided in the pilot control piping to protect the pilot valve. An indicator rod shall be provided to show valve position.
- E. Valve shall be provided with 125-pound flanged ends drilled per ANSI B16.1.
- F. Pilot actuated pressure relief valves shall be Clayton Figure 50G, OCV Series 108-3, or equal.

2.20 TELESCOPING VALVES

- A. Telescoping valves are used primarily for sludge removal, or liquid level control, and are considered to be fully open when in the lowermost position. The valve tube inside a Ductile Iron riser as show on the contract drawings. The nominal riser pipe diameter determines the valve tube diameter. V-notch, flared or baffled tube tops shall be provided as required by the Contract Drawings.
- B. Brass tubes for 10 inch nominal diameter and smaller valves shall be manufactured from seamless tube or pipe. For 12 inch and larger brass valves the tube shall be of rolled plate construction with the weld seam ground smooth. The finish O.D. of the tube is to be ±0.04 inches, cylindrical within .100 TIR and have a smooth, 125 micro inch or better surface. Stainless steel or steel tubes up through 24" size shall be manufactured from seamless pipe or tube. Steel tubes are to be fusion epoxy coated. Tube lengths shall be as shown or noted on the Contract drawings and must be of sufficient length to facilitate valve travel and maintain an appropriate insert depth. Valve tubes are to be a minimum 1/8" thick and are attached to

connecting stems by use of a lifting bail.

- C. A cast iron or stainless steel companion flange and neoprene slip seal gasket shall be provided by the valve manufacturer. The gasket must be a minimum 1/4-in thick. The inside diameter of the gasket is to be 1/8-in. smaller than the outside diameter of the valve tube to provide a friction seal. The gasket is to be sandwiched between the riser pipe flange and the companion flange. The gasket and companion flange shall include a 125 lb standard drilling pattern to match the riser pipe.
- D. On brass and PVC tubes the lifting bail shall be stainless steel construction and be fastened to the valve body with stainless steel attaching bolts. On stainless steel tubes, the bail shall be the same material as the tube and be rigidly welded to the tube.
- E. Lifts shall be handwheel type, with UHMW polyethylene thrust bearings along with a stub acme threaded type 304 stainless steel stem to provide automatic self-locking, infinite valve positioning. The standard rising stem lift shall use a galvanized steel square tube with torque nut design to prevent telescoping valve tube rotation. Alternately, where conditions require, a vee keyed shaft, with a torque plate, shall be used to prevent valve tube rotation. Handwheels shall be a minimum of 12" in diameter and shall include a clear plastic Butyrate stem cover with a Mylar strip, provided by the manufacturer, will be affixed by the contractor after installation to provide a true and accurate indication of the tube elevation by comparing it to the top of the rising stem. Stainless steel anchor bolts shall be provided for all pedestals.
- F. Lifts shall be ball bearing supported handwheel type with dial position indicator, mounted to a fabricated galvanized steel non-rising stem pedestal. The pedestal shall be manufactured with a square, main vertical member and a telescoping type torque tube. The torque tube must incorporate a square thrust pocket at the top to house a square thrust nut, to prevent rotation of the valve tube assembly. The bottom of the torque tube is attached to the lifting bail with bolts & nuts, same as rising stem lift.
- G. Where mounting conditions do not permit standard rising or non-rising stem lifts, a non-rising stem telescoping valve shall be provided. The valve bail design shall include nut pocket for NRS thrust nut and guides to prevent tube rotation. Stems shall be stub acme threaded type 304 stainless steel non-rising stem, threaded and keyed to either ball bearing supported lift, or floor box type lift. Lift shall have dial position indicator and 2" square nut to be operated by T-handle.
- H. Acceptable manufactures are US Filter/Envirex, Amwell or Engineer approved equal.

2.21 MUD VALVES

- A. Mud valves are designed for applications where sedimentateous material must be flushed from the system or for tank drains.
- B. Mud valves shall be of the Heavy Duty flange type with rising or non-rising stems as shown on the Contract Drawings. Flange, cover, yoke and stem extension connection shall be cast iron. Stems shall be stainless steel. Lifting nuts shall be bronze. On non-rising stem models the stem is to be protected by a cast iron shroud with drain hole.
- C. Seating surfaces are bronze and of flat configuration. Flange drilling on Frame shall be suitable for mounting to flange per ASA-B-16.1 (125 lbs Drilling).
- D. Gate will be operated by a Tee-Handle on a standard AWWA 2' valve nut or with stainless steel stem extension to the required height.
- E. When shown on contract drawings, pedestal lifts, stem guides, and wall brackets shall be

furnished by the valve manufacturer to make a complete and operable unit.

- F. On rising stem valves, stem guides shall be provided such that the L/r ratio of the unsupported part of the stem shall not exceed 200.
- G. Paint and coatings shall be applied in accordance with the manufacturer's recommendations.
- H. Acceptable manufacturers are Clow Valve Co, M&H Valve Co or Engineer Approved equal.

2.22 MANUAL VALVE OPERATORS

- A. Unless otherwise shown or specified, all valves shall be furnished with manual operators as follows:

Valve		Operator
Gate Valves	Buried	Extension stem and valve box with standard operating nut
Gate Valves	Submerged or Located in Deep Vault	Extension stem with floor stand and handwheel operator
	Exposed Less than 7' above working surface	Handwheel operator
	Exposed More than 7' feet above working surface	Chainwheel operator
Globe Valves	All	Handwheel Operator
Butterfly and Plug Valves	Buried	Standard operating nut with extension stem and valve box (8 inches and smaller); or rotary manual operator with extension stem and valve box and standard operating nut (larger than 8 inches)
	Submerged or Located in Deep Vault	Rotary manual operator with extension stem and floor stand with handwheel (all sizes)
	Exposed Less than 7' above working surface	Lever operator (8 inches and smaller) or rotary manual operator and handwheel (larger than 8 inches)
	Exposed More than 7' above working surface	Rotary manual operator and chainwheel (all sizes)

- B. Operating nuts for buried or submerged valves shall be standard 2-inch square nuts and shall conform to AWWA C500, Section 19. Extension stems, valve boxes, and stem guides shall be furnished where shown, specified, or required for proper operation.
- C. Hand lever operators shall have heavy-duty, cast iron bracket, cast iron latching lever, and self-lubricating bushings and shall be capable of securing the valve at the fully open and fully closed position and a minimum of 5 intermediate positions. Lever operators shall be installed so that the lever is parallel with the axis of the pipe in which the valve is installed when the valve is fully open.
- D. Rotary manual operators for aboveground service shall be of the worm and worm gear or of

the traveling nut type. Rotary operators shall have a heavy-duty, weatherproof cast iron or steel housing with gasketed, removable cover and shall be equipped with a mechanical dial or slot type position indicator and a suitable handwheel. Manual operators shall be totally enclosed and sealed to prevent the entrance of rain, dirt, and corrosive atmospheres. Traveling nut operators shall have a grease-lubricated alloy steel screw stem, brass nut, and self-lubricating bronze bushings. Worm gear operators shall have hardened, grease-lubricated alloy steel worms and bronze worm gears. All exterior bolts and fasteners shall be bronze or stainless steel for corrosion resistance. The valve shall open with counterclockwise rotation of the handwheel.

- E. Manual rotary operators for buried or submerged service shall conform with the requirements of Item D above except the operator shall be totally enclosed and completely sealed to prevent the entrance of water and dirt. Buried or submerged operators shall be finished on the outside with a bituminous or other approved coating. Rotary operators for buried or submerged service shall be capable of withstanding 300-foot/pounds of torque on the operating nut or handwheel. A corrosion resistant, dial-type valve position indicator shall be provided at the operating nut on the extension stem of buried operators to provide a remote indication of valve position.
- F. Chain wheel operators shall be of heavy cast iron construction and shall be equipped with chain guide and looped, flexible, operating chain. Chain shall be heavily galvanized or cadmium plated and shall extend to within 60 inches of floor.
- G. All manual rotary and lever operators shall be capable of seating or unseating the valve disc under the most adverse conditions in the particular application with not more than an 80-pound pull on the handwheel or lever. Valve operators shall be capable of holding the valve in any position between fully open and fully closed without creeping or fluttering. Operators shall be provided with adjustable, mechanical, stop-limiting devices to prevent over-travel of the valve disc in the open and closed positions. Manual rotary and lever operators shall comply with all applicable requirements of AWWA C504, Sections 11.1, 11.2, and 11.3.

2.23 EXTENSION STEMS

- A. Extension stems shall be solid steel not smaller than the stem of the valve or galvanized steel pipe having an inside diameter not smaller than the outside diameter of the valve or valve operator stem. Extension stems shall connect to the valve by a flexible socket coupling. All couplings shall be pinned, keyed, or socket type.
- B. Each extension stem for buried valves shall extend to within 6 inches of the top of the valve box and shall be provided with spacers, which will center the stem in the valve box. A standard wrench nut shall be provided on the top of the extension stem. Extension stems for rising stem valves shall be stainless steel or carbon steel with bronze or stainless steel sleeves. Sleeves shall be of sufficient length and location to extend through each stem guide throughout the full vertical stem travel. Extension stems for submerged service shall be stainless steel or bronze.
- C. Stem guides shall be bronze-bushed, cast iron construction adjustable in 2 directions. Stem guides shall be installed so the unsupported length of the extension stem does not exceed 10 feet or an L/r or 200.
- D. Bevel gear extension stems shall be furnished where it is impractical to locate the floorstand directly over the valve. Such stems shall include a sufficient number of bearings to permit easy operation of the valves.

2.24 VALVE BOXES

- A. Unless shown or noted otherwise, all buried valves shall be provided with 3-piece, cast iron, extension sleeve type, valve boxes suitable for the depth of cover as shown on the Drawings.
- B. Valve boxes shall not be less than 5 inches in diameter, shall have a minimum thickness of 3/16-inch at any point, and shall be provided with suitable cast iron bases and covers. Covers shall have cast thereon an appropriate name designating the service for which the valve is intended ("W" for water, "S" for drain or waste lines). Covers in roadways shall be of the deep locking type.
- C. All parts of valve boxes, bases, and covers shall be heavily coated with a suitable bituminous finish.
- D. Valves and boxes shall be set plumb. Each valve box shall be placed directly over the valve it serves with the top of the box flush with the finished grade.

2.25 T-HANDLE OPERATING WRENCH

- A. The Contractor shall furnish 4 (four) T-handle, steel valve operating wrenches with sockets compatible with standard 2-inch square valve operating nuts.
- B. The operating wrenches shall be at least 36 inches in length.

2.26 PNEUMATIC ACTUATORS

- A. Pneumatic actuators shall be the double acting cylinder actuator type, designed for 50 psi. The actuator shall be sized to open the valve to 100% for all sizes.
- B. Each pneumatic actuator shall be furnished with a 4-way electric solenoid valve for ON/OFF operation with a manual override (NEMA4) mounted on the valve.
- C. The following accessories shall be furnished with each actuator:
 - 1. Speed control valve
 - 2. Position indicating switch
 - 3. Pressure regulator (adjustable)
 - 4. Pressure gauge; 0 to 125 psi
 - 5. Filter
 - 6. Interconnecting copper tubing between solenoid and actuator cylinder.

2.27 ELECTRIC VALVE ACTUATORS - NON-INTRUSIVE TYPE

- A. General
 - 1. The electric actuators for the motor operated valves shall be of non-Intrusive design with the capability for remote two-wire digital control interface. No substitution, or exception to the following specification will be accepted. The actuators shall be suitable for use on a nominal 460 Volt, 3 Phase, and 60-Hertz power supply.
 - 2. The actuators shall be self-contained unit consisting of electric motor, 15-bit, optical, absolute position encoder, electronic torque sensor, integral reversing starter, electronic control, protection, and monitoring package, manual override hand wheel, valve interface bushing, 32-character LCD display, and local control switches all contained in a sealed watertight enclosure suitable for NEMA 4, 4X, 6, IP68 and explosion proof as required. **Actuator shall be suitable for automatic valve positioning and modulation**

control when utilized in a rate of flow control operation.

3. All calibration shall be possible without removing any covers and without the use of any special tools. Answering simple “YES” or “NO” questions displayed on the 32-character LCD display shall perform all calibration. All local displays shall be expressed in multilingual text, no symbols on the LCD will be allowed!
4. The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel with either phase sequence of the three-phase power supply connected to the actuator.

B. Actuator Sizing

1. The actuator shall be sized to guarantee valve closure and opening at the specified differential pressure and valve opening. The safety margin of motor power available for seating and unseating the valve shall be sufficient to ensure torque switch trip at maximum valve torque with the supply voltage 10% below nominal. The operating speed shall be such as to give valve closing and opening at approximately 10-12 inches per minute unless otherwise specifically stated in the valve specification and/or valve data sheets.

C. Ambient Temperature

1. The actuator shall be capable of functioning in an ambient temperature ranging from minus 22°F (-30°C) to + 158°F (+70°C). Actual operating environment for specific valve application is as shown in the associated valve specification and/or data sheets.

D. Motor

1. The motor shall be 3-phase, 60-cycle, 460 volt with class F insulation, and a thermistor embedded within the motor windings to prevent damage due to overload. The motor shall be easily removed through the use of a plug-in connector and shaft coupling. Motor shall have the capability of removal without the need of draining oil from the actuator gearbox.

E. Power Transmission

1. The power transmission shall be completely bearing – supported, and consist of a hardened alloy steel worm and bronze worm gear, oil-bath lubricated using synthetic oil designed specifically for extreme pressure gear transmission service. Where the actuator operates gate valves or large diameter ball or plug valves, the drive shall incorporate a lost-motion hammer-blow feature. For rising spindle valves, the output shaft shall be hollow to accept a rising stem and incorporate thrust bearings of the ball or roller type at the base of the actuator, and the design should be such as to permit the gear case to be opened for inspection or disassembled without releasing the stem thrust or taking the valve out of service.

F. Hand Operation

1. A hand wheel and a de-clutch (hand/auto selection) lever shall be provided for manual operation. The hand wheel drive must be mechanically independent of the motor drive, and any gearing should be such as to permit emergency manual operation in a reasonable time. The hand wheel shall not rotate during electric operation nor can a seized motor prevent manual operation. Hand wheel is engaged when the motor is declutched by a lever or similar means. Energizing the motor shall restore the actuator automatically to motor operation. The de-clutch (hand/auto selection) lever shall be padlockable. Lost

motion “hammer blow” effect shall be provided with both direct and independently geared hand wheels.

2. Clockwise operation of the hand wheel shall give closing movement of the valve unless otherwise stated in the job specification.

G. Drive Bushing

1. The actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gearbox input shaft. Normally the drive bushing shall be positioned in a detachable base of the actuator. Thrust bearings, when housed in a separate thrust base, should be of the sealed-for-life type.

H. Position & Torque Sensing

1. A 15 – bit optical absolute position encoder, shall sense valve position. Position setting range shall be: 2 to 100,000 turns, with a maximum angular resolution of 7.5° degrees of actuator drive sleeve output position at the valve stem. Open and closed positions shall be stored in permanent, non-volatile memory. The encoder shall measure valve position at all times, including both motor and hand wheel operation, with or without 3 – phase power, and without use of a battery. Use of batteries in the actuators shall not be acceptable.
2. An electronic torque sensor shall be included. The torque limit may be adjusted from 40% to 100% of rating in 1% increments. The motor shall be de-energized if the torque limit is exceeded. A boost function shall be included to prevent torque trip during initial valve unseating, and a “Jammed Valve” protection feature, with automatic retry sequence shall be incorporated to de-energize the motor if no movement occurs.
3. No mechanical torque sensing system using springs, or washers will be accepted.

I. Remote Valve Position / Actuator Status Indication

1. Four latched contacts rated 250 Vac / 30 Vdc, 5 amps shall be provided for remote indication of valve position, configured as 1-N/O and 1-N/C for both the open and closed positions. The remaining contacts shall be configured to represent any other actuator status; mid-travel position, switched to local, over torque, motor over temperature, manual operation, switched to remote, switch to stop, valve moving, close torque switch trip, open torque switch trip, hardware failure, ESD active, or valve jammed.
2. Monitor Relay
 - a. A monitor relay shall be included and shall trip when the actuator is not available for remote operation. Both N/O and N/C contacts shall be included, rated 250 Vac / 30 Vdc, 5 amps. The yellow LED shall blink when the monitor relay is active. The relay must de-energize if any of the following events occur:
 - 1) Loss of one or more of the 3-Phase incoming power supply.
 - 2) Loss of internal control power supply.
 - 3) Jammed valve detected.
 - 4) Motor over temperature is active, unless thermostat is configured to OFF.
 - 5) Selector switch is in the “LOCAL” mode.

- 6) Selector switch is in the “STOP” mode.
 - b. The actuator must also include monitoring capability for the following parameters:
 - 1) Valve over-torque.
 - 2) Inhibit signal active.
 - 3) ESD signal active
 - c. Provision shall be made in the design for the addition of a contact less transmitter to give a 4-20mA analog signal corresponding to valve travel for remote indication when required.
3. Local Position Indication
- a. A 32-character, Liquid Crystal Display (LCD) for ease of viewing shall be included to display valve position as a percent of open, 0 – 100%, and current actuator status. “STATUS OK” shall be displayed for an operable actuator. If the actuator is not operable, the appropriate alarm shall be displayed in easy to understand English text (symbols are not acceptable for local indication). the appropriate alarm shall be displayed. The alarm shall be continuously displayed until the actuator is operable. Red, green, and yellow LED’s shall be included for local open, close, stopped, and moving indication.
4. Integral Starter And Transformer
- a. The reversing contactor shall be mechanically interlocked to prevent simultaneous energizing of the open and close coils. The control module shall also include an auto reversal delay to inhibit high current surges caused by rapid motor reversals. The reversing contactor, as standard shall be rated for 150 motor starts per hour. Optional solid state reversing contactor shall be available for high rate modulating service up to 1200 motor starts per hour.
 - b. The control transformer shall include vacuum-impregnated coils and dual primary fuses. A phase correction circuit shall be included to correct motor rotation faults caused by incorrect site wiring. The phase correction circuit shall also detect the loss of a phase and disable operation to prevent motor damage.
5. Integral Local Control Switches
- a. A padlockable LOCAL-STOP-REMOTE switch and an OPEN-CLOSE switch shall be included for local valve actuator control. The control switches shall not penetrate the controls cover and shall be designed to electrically isolate the actuator’s internal components from the external environment.
 - b. It shall be possible to select maintained or non-maintained local control. The local controls shall be arranged so that the direction of valve travel can be reversed without the necessity of stopping the actuator.
6. Remote Control Facilities
- a. Actuator must have configurable remote control as 2, 3, or 4 wires for open-stop-close control. Terminals must also be provided for ESD (Emergency Shutdown) and inhibit Movement commands. The ESD signal shall override any existing signal (except LOCAL, STOP, and INHIBIT) and send the valve to it’s configured emergency position. The actuator configuration shall be capable of overriding

LOCAL, STOP, and/or INHIBIT.

- b. The actuator must be capable of receiving remote control commands powered by external power source of 24, to 125 volts ac, or dc. Automatic switching.
 - c. The actuator must be capable of powering remote control function loops of 24Vdc, or 120 Vac.
7. Wiring and Terminals
- a. All field terminations shall be located in a termination chamber that is separately sealed from all other actuator components. Site wiring shall not expose actuator components to the environment. The internal sealing within the termination chamber is suitable for NEMA 4, 6, and IP68. The chamber shall include screw-type terminals, 3 - power and 50 - control, for site connections.
 - b. Three conduit entries, available as: (2) – 1.25” NPT and (1) – 1.5” NPT shall be supplied.
8. Paint Coating
- a. The actuator shall be coated with a high-solids epoxy E-coat primer, and then finished-coated with a National Blue Color, polymer powder coat. The coating system shall be suitable for an ASTM B117 salt spray test of 1500 hours.
9. Startup Kit
- a. Each actuator shall be supplied with a startup kit comprising installation instruction, electrical wiring diagram, and sufficient spare cover screws and seals to make good any site losses during the commissioning period.
10. Performance Test Certificate
- a. A report confirming successful completion of testing shall be included with actuator.
 - b. The actuator designs shall have been tested to demonstrate electromagnetic compatibility with the following:
 - 1) EFT Immunity; EN 50082-2
 - 2) Conducted Immunity; EN 50082-2
 - 3) Conducted Immunity; Mains (power) Harmonic Distortion per MIL-STD-461 Method conducted Emissions; EN 55011
 - 4) Radiated Emissions; EN 55011
 - 5) ESD Immunity; EN 50082-2
 - 6) Radiated Immunity; EN 50082-2
 - 7) Radiated Immunity; 1 – 2 Ghz Per IEC 801-3
 - 8) CS01 & CS02
 - 9) Surge Immunity; IEC 1000-4-5 & ANSI / IEEE C62.41 to 4 KV
 - 10) Magnetic Field Immunity; IEC 1000-4-8
 - 11) Vibration and seismic capability shall be in accordance with MIL-STD-167

12) IEEE-344-1975, and IEC68-2-6.

11. Warranty

- a. Each actuator shall be warranted for a minimum of 24 months of operation up to a maximum of 36 months from shipment.

2.28 INTRUSIVE TYPE ACTUATORS

A. Gear Housing

1. Housing material shall be cast aluminum
2. Lubrication shall be Exxon-O grease
3. Gear reduction shall be triple reduction with double worm and spur gear. Spur gear and worm gear shall be constructed of alloy bronze with the worm being alloy steel. Spur gear shall be constructed of heat treated steel.

B. Electrical Compartment Covers

1. Electrical compartment covers shall be constructed of cast aluminum with o-ring seals. All hardware shall be nickel plated carbon steel, non-captive.

C. Motor

1. Motor shall be squirrel cage type induction for 3 phase and permanent split capacitor for 1 phase. Power supply shall be 1 phase, 60 hertz, 115 volt.
2. Dynamic torque shall be nominal 20% of start torque.
3. Insulation shall be Class F.
4. Thermal protection shall be supplied with two (2) Class B thermal contacts embedded within the motor windings.

D. Limit Switch

1. Limit switch shall be Type-Cam operated micro switches, contacts shall be 8 SPDT.

E. Position Indication

1. Actuator shall be supplied with dial indicator to show 0-100% of valve travel.

F. Enclosure

1. Enclosures for all actuators shall be as follows:
 - a. Water Proof - NEMA 4
 - b. Explosive Proof Class 1, Group B, C & D, Division 1 & 2 Service and Class II, Groups E, F & G.

G. Handwheel

1. Actuator shall be supplied with cast aluminum declutchable handwheels.

H. Output Drive

1. Actuator shall be supplied with externally splined steel torque bushing with no internal machining.

I. Mounting Base

1. Mounting base shall be MSS (English Taps).

J. Painting

1. Actuator shall be painted with black LPS-112. Coating shall be 'E' coat or TNEMEC 69 High Build Epoxoline II. Coating shall be suitable for 500 hour salt spray. Actuator shall be suitable for operation with temperatures between -20°F and 150°F.

K. Acuator Controls

1. Three Phase units shall include:
 - a. Transformer
 - b. Reversing contactor
 - c. Dual primary fuses
 - d. Secondary fuses
 - e. Positioner board
 - f. Local position indication
 - g. 100 ohm feedback potentiometer
 - h. Pushbutton station with 3 buttons Open / Stop / Close
 - i. 2 LED lights
 - j. 3 position selector switch (Local, Off, Remote)
2. Single phase units shall include:
 - a. Same controls as three (3) phase units with the addition of capacitors for control of the 1 phase motors.

L. Acceptable Manufacturers

1. Actuator shall be manufactured by Limitorque, Inc.

PART 3 EXECUTION

3.01 FACTORY TESTS

- A. All valves shall be tested at the point of manufacture for proper and unobstructed operation and for leakage and adequacy of design.
- B. Iron body gate valves shall be tested in accordance with AWWA C500.
- C. Butterfly and plug valves shall be tested in accordance with AWWA C504.
- D. Iron body check valves shall be tested in accordance with AWWA C508.
- E. All other valves shall be given an operation test, a leakage test at rated pressure differential, and a hydrostatic test at 2 times rated pressure. During the hydrostatic test, there shall be no leakage through the metal, the end joints, or the shaft or stem seal, nor shall any part be permanently deformed. During the leakage test, leakage shall not exceed that permitted by ANSI B16.104, Class IV, for metal seated valves and Class VI for resiliently seated valves.

3.02 INSTALLATION

- A. All valves shall be installed in strict conformance with the Drawings and approved ship drawings and manufacturer's instructions.

- B. Unless otherwise shown or specified, butterfly valves shall be installed with stems in the horizontal position.
- C. Double plate, clapper type check valves in horizontal piping shall be installed with the stem in the vertical position.
- D. Swing check valves shall be installed only in a horizontal position. Lever shall be free to operate without obstruction.
- E. All underground valves shall be installed using a valve box as specified herein.
- F. Four-way solenoid valves shall exhibit no leakage in either position.
- G. Valves shall be installed in such a way that operators and packing are easily accessible. Valves with field replaceable seats shall be installed with sufficient clearance to permit removal of valve bonnet and stem without removing valve from the line.

3.03 FIELD TESTING

- A. Following installation, all valves shall be tested by the Contractor under the anticipated operating conditions. The ability of the valves to operate properly without leakage, binding, sticking, fluttering, or excessive operating torque shall be demonstrated to the satisfaction of the Engineer. The Contractor shall at his own expense adjust and/or replace any valve as necessary to assure satisfactory operation.
- B. Following installation and testing, all ferrous and non-machined surfaces of exposed valves, operators, floorstands, and stem guides shall be field primed and painted with a finish suitable for the intended service in accordance with requirements of the section entitled "Painting" of these Specifications.

END OF SECTION

SECTION 40 05 58

SLIDE GATES

PART 1 - GENERAL

1.01 SCOPE

- A. Work covered by this Section includes furnishing all labor, equipment, and materials required to install and test fabricated stainless steel slide gates and complete with slides and frames and appurtenances, as shown on the Drawings and/or specified herein.

1.02 RELATED WORK

- A. Installation of anchor bolts is included in Division 05, but anchor bolts shall be furnished under this Section.
- B. Field painting is included in Section 09 90 00.

1.03 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 "Submittal Procedures" of these Specifications, copies of all materials required to establish compliance with this Section. Submittals shall include at least the following:
 - 1. Certified drawings showing details of construction and dimensions
 - 2. Descriptive literature bulletins and/or catalogs of each product.
 - 3. The total weight of each item
 - 4. A complete bill of materials
 - 5. Additional submittal data, where noted with individual pieces of equipment.
- B. Manufacturer's Installation and Application Data
- C. Complete operating and maintenance instructions shall be furnished for all equipment specified herein accordance with the General Conditions and Division 01.
- D. In the event that it is impossible to conform to certain details of the specifications due to different manufacturing techniques, describe completely all non-conforming aspects.

1.04 REFERENCE STANDARDS

- A. Design, manufacturing and assembly of elements of the products herein specified shall be in accordance with the standards of the below listed organizations.
 - 1. American Society for Testing and Materials (ASTM)
 - 2. Underwriters Laboratories (UL)
 - 3. Factory Mutual (FM)
- B. Where reference is made to a standard of one of the above, or other organizations, the version of the standard in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. Qualifications
 - 1. All products specified under this Section shall be standard products of proven ability as manufactured by competent organizations that are fully experienced, reputable and

qualified in the manufacture of the products to be furnished. The products shall be designed, constructed and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed.

2. All products furnished under this Section shall be new and unused and shall be the standard products of manufacturers having a successful record of manufacturing and servicing the equipment and systems specified herein for a minimum of five (5) years.

B. Services of Manufacturer's Representatives

1. Each manufacturer of the products listed below shall furnish the services of a competent and experienced factory representative who has complete knowledge of proper installation, operation and maintenance of the equipment for a period of not less than one 8-hour day (exclusive of travel time) to inspect the installed equipment, conduct final performance testing, and provide operating and maintenance instructions to the plant personnel.
2. The instruction period shall be scheduled at least ten days in advance with the Owner and shall take place prior to plant start-up and acceptance by the Owner. The final approved copies of operation and maintenance manuals must have been delivered to the Engineer prior to scheduling the instruction period with the Owner.

1.06 DELIVERY, STORAGE AND HANDLING

A. Reference is made to Section 01 60 00 for additional information.

B. Packing and Shipping

1. Care shall be taken in loading, transporting and unloading to prevent injury to the gates, appurtenances, or coatings. Equipment shall not be dropped. All gates and appurtenances shall be examined before installation. Any piece of equipment that is found to be defective shall not be installed. Any damage to the coatings shall be repaired as acceptable to the Engineer.
2. Exposed stems shall be coated with a protective oil film that shall be maintained until the unit is installed and placed into service.
3. Any corrosion in evidence at the time of acceptance by the Owner shall be removed, or the valve shall be removed and replaced.

1.07 MAINTENANCE

A. Spare Parts

1. Manufacturer's recommended spare parts for the initial year of operation.
2. Spare parts shall be properly bound and labeled for easy identification without opening the packaging and suitably protected for long term storage in a humid environment.

B. Special Tools

1. Furnish one set of all special tools required for normal operation and maintenance of the equipment.
2. Tools shall be furnished in a suitable steel case, clearly and indelibly marked on the exterior to indicate the equipment for which the tools are intended.

1.08 GUARANTEE

- A. The equipment and installation shall be fully guaranteed by the Contractor for a period of minimum one year from the date of final acceptance by the Owner. The guarantee shall cover any and all defects in workmanship or materials that may develop in this specified time. Refer to the General Conditions of these specifications for additional information.

PART 2 - PRODUCTS

2.01 DESIGN CRITERIA

- A. Slide gates and shall be reinforced as required for a deflection under the maximum design head of not more than $1/360$ of the span of the gate. Gates wider than 7 feet shall be designed for deflection of less than $1/720$ of the span of the gate under the designed head.
- B. The following is the allowable gate leakage when subjected to the specified head conditions included in the gate schedule.
 - 1. Under a seating head condition, the leakage shall not exceed 0.1 gallon per minute per foot of perimeter.
 - 2. For unseating head conditions up to a maximum of 20 feet, the leakage shall not exceed 0.2 gallon per minute per foot of seating perimeter.
- C. Manufacturers
 - 1. Hydro Gate
 - 2. Fontaine Aquanox
 - 3. Whipps, Inc.
 - 4. Golden Harvest
 - 5. Mcwane PI
 - 6. Waterman

2.02 FABRICATED SLIDE GATES

- A. Fabricated slide gate disc shall be a flat plate suitably reinforced to withstand the required head conditions. If flush-bottom closure is required, a resilient seal shall be:
 - 1. Attached to the lower edge of the disc to seat against a stop bar attached to the frame along the invert of the gate.OR
 - 2. Attached at the gate invert, the slide shall close on a flush invert rubber seat/seal secured in the bottom member of the gate frame
- B. The frame shall consist of a standard guide extending down both sides of the gate and across the invert. The frame shall be suitable for embedding in concrete unless otherwise shown on the plans.
- C. If the gate is to be self-contained, guides shall extend above the opening to support a structural yoke. The operating bench stand or floor stand shall be mounted on the yoke.
- D. The operating stem shall be the rising-stem type and shall be attached to the gate disc.
- E. The gate disc and frame shall be constructed from stainless steel.
- F. Wall brackets to support stem shall be fabricated from Type 304 stainless steel. Distances from wall to centerline of stem are as shown on drawings or indicated in the gate schedule.

2.03 STEMS

- A. Operating stems shall be of a size to safely withstand, without buckling or distortion, the stresses induced by normal operating forces. Stems shall be designed to transmit in compression at least 2 times the rated output of the floor stand or bench stand with a 40-pound effort on the crank or handwheel.
- B. The threaded portion of the stem shall have machine-cut or machine rolled threads of the Acme type.
- C. Stems of more than 1 section shall be joined by bronze couplings threaded and keyed or bored and pinned to the stems. All threaded and keyed couplings of the same size shall be interchangeable.
- D. Manually operated rising stem gates shall be provided with an adjustable bronze or aluminum stop collar on the stem above the floor stand lift nut.
- E. All stems shall be fabricated from Type 304 stainless steel and shall be not less than 1½ inches in diameter.
- F. Provide stem covers manufactured of clear polycarbonate or PVC to provide visual indication of gate position. Stem covers shall be provided with vent holes to limit the condensation build up.

2.04 MANUAL OPERATOR FLOOR STANDS

- A. Manual operation shall be by handwheel or crank-operated floor stands or bench stands as shown on the plans. Handwheel operated type shall be without gear reduction and crank-operated type shall have either a single- or double-gear reduction depending upon the lifting capacity required. Each type shall be provided with a threaded cast bronze lift nut to engage the operating stem.
- B. Tapered roller bearings shall be provided above and below a flange on the operating nut to support both opening and closing thrusts.
- C. Floor stands shall operate the gates with not greater than 40-lb. pull on the crank or handwheel. Gears, where required, shall be steel or cast iron with machine cut teeth designed for smooth operation. The pinion shafts on crank-operated floor stands, either single or double, shall be supported on tapered roller bearings or needle bearings. All components shall be totally enclosed in a cast iron case and cover. Positive mechanical seals shall be provided on the operating nut and the pinion shafts where they extend from the cast iron case or gear box to retain lubricant and to exclude moisture and dirt. Lubricating fittings shall be provided for lubrication of all gears and bearings.
- D. The removable crank shall be aluminum or cast iron with a revolving brass grip. Floor stands shall include a stainless steel or cast iron pedestal design to position the input shaft approximately 36 inches above the operating floor.

2.05 REMOTE VALVE POSITION / ACTUATOR STATUS INDICATION

- A. Remote Valve Position Indication
 - 1. Four latched contacts rated 250 Vac/30 Vdc, 5 amps shall be provided for remote indication of valve position, configured as 1-N/O and 1-N/C for both the open and closed positions. The remaining contacts shall be configured to represent any other actuator status; mid-travel position, switched to local, over torque, motor over temperature, manual operation, switched to remote, switch to stop, valve moving, close

torque switch trip, open torque switch trip, hardware failure, ESD active, or valve jammed.

B. Monitor Relay

1. A monitor relay shall be included and shall trip when the actuator is not available for remote operation. Both N/O and N/C contacts shall be included, rated 250 Vac/30 Vdc, 5 amps. The yellow LED shall blink when the monitor relay is active. The relay must de-energize if any of the following events occur:
 - a. Loss of one or more of the 3-Phase incoming power supply.
 - b. Loss of internal control power supply.
 - c. Jammed valve detected.
 - d. Motor over temperature is active, unless thermostat is configured to OFF.
 - e. Selector switch is in the "LOCAL" mode.
 - f. Selector switch is in the "STOP" mode.
2. The actuator must include monitoring capability for the following parameters:
 - a. Valve over-torque
 - b. Inhibit signal active
 - c. ESD signal active
3. Provision shall be made in the design for the addition of a contact less transmitter to give a 4-20mA analog signal corresponding to valve travel for remote indication when required

C. Local Position Indication

1. A 32-character, Liquid Crystal Display (LCD) for ease of viewing shall be included to display valve position as a percent of open, 0 – 100%, and current actuator status. "STATUS OK" shall be displayed for an operable actuator. If the actuator is not operable, the appropriate alarm shall be displayed in easy to understand English text (symbols are not acceptable for local indication). the appropriate alarm shall be displayed. The alarm shall be continuously displayed until the actuator is operable. Red, green, and yellow LED's shall be included for local open, close, stopped, and moving indication.

D. Integral Starter And Transformer

1. The reversing contactor shall be mechanically interlocked to prevent simultaneous energizing of the open and close coils. The control module shall also include an auto reversal delay to inhibit high current surges caused by rapid motor reversals. The reversing contactor, as standard shall be rated for 150 motor starts per hour. Optional solid state reversing contactor shall be available for high rate modulating service up to 1200 motor starts per hour.
2. The control transformer shall include vacuum-impregnated coils and dual primary fuses. A phase correction circuit shall be included to correct motor rotation faults caused by incorrect site wiring. The phase correction circuit shall also detect the loss of a phase and disable operation to prevent motor damage.

E. Integral Local Control Switches

1. A lockable LOCAL-STOP-REMOTE switch and an OPEN-CLOSE switch shall be included for local valve actuator control. The control switches shall not penetrate the controls cover and shall be designed to electrically isolate the actuator's internal components from the external environment.
2. It shall be possible to select maintained or non-maintained local control. The local controls shall be arranged so that the direction of valve travel can be reversed without the necessity of stopping the actuator.

F. Remote Control Facilities

1. Actuator must have configurable remote control as 2, 3, or 4 wires for open-stop-close control. Terminals must also be provided for ESD (Emergency Shutdown) and inhibit Movement commands. The ESD signal shall override any existing signal (except LOCAL, STOP, and INHIBIT) and send the valve to its configured emergency position. The actuator configuration shall be capable of overriding LOCAL, STOP, and/or INHIBIT.
2. The actuator must be capable of receiving remote control commands powered by external power source of 24, to 125 volts ac, or dc. Automatic switching.
3. The actuator must be capable of powering remote control function loops of 24Vdc, or 120 Vac.

G. Wiring and Terminals

1. All field terminations shall be located in a termination chamber that is separately sealed from all other actuator components. Site wiring shall not expose actuator components to the environment. The internal sealing within the termination chamber is suitable for NEMA 4, 6, and IP68. The chamber shall include screw-type terminals, 3 - power and 50 - control, for site connections.
2. Three conduit entries, available as: (2) – 1.25" NPT and (1) – 1.5" NPT shall be supplied.

H. Paint Coating

1. The actuator shall be coated with a high-solids epoxy E-coat primer, and then finished-coated with a National Blue Color, polymer powder coat. The coating system shall be suitable for an ASTM B117 salt spray test of 1500 hours.

I. Startup Kit

1. Each actuator shall be supplied with a startup kit comprising installation instruction, electrical wiring diagram, and sufficient spare cover screws and seals to make good any site losses during the commissioning period.

J. Performance Test Certificate

1. A report confirming successful completion of testing shall be included with actuator.
2. The actuator designs shall have been tested to demonstrate electromagnetic compatibility with the following:
 - a. EFT Immunity; EN 50082-2
 - b. Conducted Immunity; EN 50082-2

- c. Conducted Immunity; Mains (power) Harmonic Distortion per MIL STD-461 Method conducted Emissions; EN 55011
 - d. Radiated Emissions; EN 55011
 - e. ESD Immunity; EN 50082-2
 - f. Radiated Immunity; EN 50082-2
 - g. Radiated Immunity; 1 – 2 Ghz Per IEC 801-3
 - h. CS01 & CS02
 - i. Surge Immunity; IEC 1000-4-5 & ANSI / IEEE C62.41 to 4 KV
 - j. Magnetic Field Immunity; IEC 1000-4-8
 - k. Vibration and seismic capability shall be in accordance with MIL-STD-167,
 - l. IEEE-344 and IEC68-2-6.
3. Warranty
- a. Each actuator shall be warranted for a minimum of 24 months of operation up to a maximum of 36 months from shipment.

K. Acceptable Manufacturers

- 1. Actuator shall be manufactured by Limitorque, Inc.

2.06 PORTABLE TRIPOD-TYPE OPERATORS

- A. The gate manufacturer shall supply one (1) tripod-type operator. This operator shall be electrically operated with reversing features and an overload release clutch for the protection of the operated equipment. The tripod-type operator shall operate from a 110 volt, single-phase power supply. The power cord shall a 7'-6" grounding type cord furnished with the unit. The on-off switch must be held in during operation. When released the drive unit shall stop.
- B. The tripod shall be of lightweight construction, adjustable from 32" to 42" to vary the height of the output shaft to coincide with the input pinion shaft of the actuator to be operated.
- C. The overload release clutch is of the spring loaded, drive-pawl type, which releases instantly a preset, predetermined torque. Disc friction clutches or shear pins are not to be used.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall be in strict accordance with the manufacturer's written instructions and recommendations in the locations shown on the Drawings.
- B. Slide gate frames and plates shall be checked prior to installation for projections or warpage that would promote excessive leakage. Defective gates shall be removed and replaced.
- C. Slide gate frames shall be installed true to the lines and elevations shown and accurately aligned. Frames shall be internally braced and adequately supported during concrete placement and/or installation.
- D. The ability of each slide gate to operate easily without binding or excessive leakage or wear shall be demonstrated to the satisfaction of the Engineer.

3.02 TESTING

- A. All gates shall be field tested to ensure all items are in compliance with this Section. Each gate shall be cycled through a minimum of three full open/close cycles.
- B. Gates shall operate without binding, scraping, or distorting. The effort to open and close the gate shall be measured and shall not exceed the maximum torque specified.
- C. The leakage rate shall not exceed 0.1 gpm/ft of seating perimeter. Additional seals shall be provided as required to insure the leakage requirement is met.

END OF SECTION

SECTION 40 41 13
PROCESS PIPING HEAT TRACING

PART 1 - GENERAL

1.01 SCOPE

- A. Work covered by this section includes furnishing all labor, materials, and equipment required to furnish and install process pipe heat tracing and accessories as specified herein and/or shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Shop Drawings, Product Data and Samples – Section 01 33 00
B. Operation and Maintenance Manual – Section 01 70 00

1.03 SHOP DRAWINGS AND ENGINEERING DATA

- A. Complete shop drawings and engineering data shall be submitted to the Consultant Engineer in accordance with requirements of the section entitled “Shop Drawings, Product Data and Samples” of these Specifications.

1.04 STORAGE AND PROTECTION

- A. Heat tracing materials shall be stored indoors in a clean, dry place. Mastics and adhesives shall be stored at a temperature of 50° F to 90° F.
B. Insulation shall be stored in its original packaging until used. Damaged heat tracing shall be removed from the site.

1.05 GUARANTEE

- A. Provide a guarantee against defective or deficient workmanship and materials in accordance with requirements of the Section 01 70 00 Warranties and Bonds of these Specifications.

PART 2 – PRODUCTS

2.01 HEAT TRACING

- A. Piping shall be heat traced for freeze protection where exposed to subfreezing temperatures or where shown or specified on the Drawings. All heat traced piping shall be insulated. All necessary fittings, tape, end seals, and other accessories shall be furnished and installed.
B. Heat tracing shall be of the parallel circuit, self-limiting, semiconductor type electric resistance heat tracing suitable for cut-to-length field installation. Heat tracing shall be waterproof and chemical resistant. Heat tracing shall be UL listed and FM approved for Class, 1 Division 2 hazardous locations
C. Heat tracing shall have a watt per foot rating at 50° F as follows:

Pipe Size (in.)	Insulation Thickness (in.)	Watts Per Foot
1 and smaller	1	2.0
1½	1½	2.0
2	1½	2.2
2½	1½	2.5

3	1½	2.9
4	1½	3.5
6	2	3.9
8	2	4.8
10	2	5.8
12	2	6.7

- D. Heat tracing strip shall have a flat profile and shall be furnished with a noncorrosive metal braid shield or jacket. Unless otherwise shown or required, heat tracing shall operate at 120 volts, 60 hertz, and single phase.
- E. Heat tracing rated 5 watts per foot or less shall be suitable for ambient temperature control and shall not be damaged if crossed in direct contact.
- F. Heat tracing rated 5 watts per foot or less shall be controlled by a separate, liquid-filled, ambient sensing thermostat. Thermostat shall have a tamperproof calibrated setpoint dial SPST or SPDT contacts rated minimum 20 amps at 120 volts, a cast aluminum NEMA 4 enclosure.
- G. Heat tracing rated 5 watts per foot or less shall be short circuit protected through integral fusing.
- H. Heat tracing rated in excess of 5 watts per foot shall be controlled by a separate, pipeline sensing, liquid-filled thermostat with stainless steel bulb and a minimum 10 feet of flexible stainless steel capillary tubing. Thermostat shall have a tamperproof, calibrated setpoint dial, SPST or SPDT contacts rated minimum 20 amps at 120 volts, 6° F differential, and a cast aluminum NEMA 4 enclosure.
- I. Thermostats shall be furnished by the heat tracing manufacturer and shall be adjustable over an operating range of 25° F to 90° F.
- J. A heavy-duty, oil-tight indicator light in a separate NEMA 4 enclosure shall be provided at the thermostat to indicate when the heat-tracing circuit is energized.
- K. Circuit breakers used to protect electric heat tracing circuits shall be of the ground fault interrupter type.

PART 3 – EXECUTION

3.01 INSTALLATION OF HEAT TRACING

- A. Heat tracing shall be installed in a continuous straight strip along the pipe or spirally wrapped as required to obtain the necessary watt density. An additional turn shall be taken around valves, fittings and strainers.
- B. Length of circuits shall not exceed the rating of the controlling thermostat or the maximum circuit length specified by the manufacturer.
- C. Heat tracing shall be secured to the pipe using heat-resistant tape at intervals of 12 inches or less. Heat tracing shall be protected from damage and from the weather until weather resistant insulation jackets are in place.

- D. After installation and before applying insulation, test the system for grounds and short circuits using a 500 Vdc meter. Insulation resistance should exceed 10,000 megohms per 250 feet.

END OF SECTION

SECTION 40 42 13
PROCESS PIPING INSULATION

PART 1 - GENERAL

1.01 SCOPE

- A. Work covered by this section includes furnishing all labor, materials, and equipment required to furnish and install process pipe insulation and accessories as specified herein and/or shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Shop Drawings, Product Data and Samples – Section 01 33 00
- B. Operation and Maintenance Manual – Section 01 70 00

1.03 SHOP DRAWINGS AND ENGINEERING DATA

- A. Complete shop drawings and engineering data shall be submitted to the Consultant Engineer in accordance with requirements of the section entitled “Shop Drawings, Product Data and Samples” of these Specifications.

1.04 STORAGE AND PROTECTION

- A. Insulation materials shall be stored indoors in a clean, dry place. Mastics and adhesives shall be stored at a temperature of 50° F to 90° F.
- B. Insulation shall be stored on end in its original packaging until used. Damaged insulation shall be removed from the site.

1.05 GUARANTEE

- A. Provide a guarantee against defective or deficient workmanship and materials in accordance with requirements of Section 01 70 00 Warranties and Bonds of these Specifications.

PART 2 – PRODUCTS

2.01 FIBERGLASS PIPE INSULATION

- A. On all exterior piping which is not self-draining and where shown or required to prevent condensation or freezing, pipe shall be furnished with fiberglass insulation as specified herein. Insulation materials, including mastics and adhesives, shall have a flame spread of less than 25 and a fuel contributed and smoke generated rating of less than 50, in accordance with ASTM E84.
- B. Insulation shall be heavy density (4.0 PCF average) sectional fiberglass pipe insulation, preformed in half-cylinder sections approximately 3 feet long. Insulation shall have a thermal conductivity not exceeding 0.25 Btu-in./hr.-sq.ft.-°F at 75° F. Insulation shall have a white, factory-applied, vapor barrier jacket with overlapping flap for field sealing. Factory –applied vapor barrier jacket shall be a glass reinforced, Kraft-foil laminate having a water vapor permeability of 0.02 perms or less and a puncture resistance of at least 50 ounce/inch tear. Insulation shall fit the specified pipe size and shall be suitable for operating temperatures from -60° F to +450° F. Outside diameter of insulation shall correspond to an iron pipe size. Insulation shall be as manufactured by Owens-Corning, Johns-Manville, Certainteed, or equal. Size of insulation shall be as follows:
 - 1. One-inch Thickness
 - a. Hot and cold water piping sizes 1 ¼ inch and smaller.

- b. Steam condensate piping.
 - c. Low pressure steam supply piping in sizes 1 ¼ inch and smaller.
 - d. Space heating and cooling pipe in sizes 1 ¼ inch and smaller.
 - e. Drain piping and chemical piping.
 - f. Process piping in sizes 1 ¼ inches and smaller.
 - g. One and one-half inch Thickness
 - h. Hot and cold piping in sizes 1 ½ inch larger.
 - i. Low pressure steam supply piping in sizes 1 ½ inch and larger.
 - j. Space heating and cooling piping in sizes 1 ½ inch through 5 inches.
2. Two-inch Thickness
- a. Process piping, in sizes 6 inches and larger.
 - b. Fitting and valve insulation shall be premolded fiberglass insulation as manufactured by Insul-Caustic Corporation or equal or fabricated from mitered segments of pipe insulation.
 - c. The outer layer of insulation shall have a white, flame retardant, vapor barrier jacket made up of white vapor seal mastic and a membrane of open weave glass cloth between coats of mastic. Vapor seal mastic for field-applied jacket shall be Insul-Caustic I-C 520, Benjamin Foster 60-36, or equal, white in color. Glass cloth shall be 20x20 mesh, 1.5 ounce/square yard, Owens Corning No. 10, Benjamin Foster Mast-A-Fab, or equal. Alternately, straight sections of pipe insulation may be furnished with factory-applied white vapor barrier jacket with overlaps for field sealing with adhesive.
 - d. All fiberglass pipe insulation exposed to the weather water spray or located within 7 feet of the floor or working surface shall have a 0.013-inch thick, embossed aluminum protective jacket with 3/16-inch corrugations designed for field installation over the vapor barrier jacket. Aluminum jacket shall have 2-inch overlaps at longitudinal and girth seams and shall be held in place with ½ inch wide, 0.02-inch thick aluminum bands at 9-inch centers. Jacket for fittings shall be prefabricated aluminum fitting covers as manufactured by Preformed Metal Products Company, Smith Products, or equal. Jacket shall completely cover all exposed insulation including fittings and valves (except handles).

2.02 ELATOMERIC PIPE AND TUBE INSULATION

- A. Closed-cell, flexible pipe insulation shall be provided where shown on the Drawings or required to prevent condensation or freezing.
- B. Elastomeric pipe insulation shall be supplied in preformed tubular sections without longitudinal joints or seams and shall be designed to slip over straight pipe section.
- C. Elastomeric pipe insulation shall be suitable for operating temperatures of -40° F to +220° F and shall comply with ASTM C534, Type 1, or ASTM D1056, SBE 41-42. Water absorption shall not exceed 0.17 perm-in. when tested in accordance with ASTM C355. Flame spread shall not exceed 25 in accordance with ASTM E84.
- D. Thickness of insulations shall be as follows:
 - 1. ½-inch Thickness

- a. Hot and cold water piping running masonry walls
2. $\frac{3}{4}$ -inch Thickness
 - a. Refrigerant and hot gas bypass piping in sizes 1 inches and smaller.

PART 3 – EXECUTION

3.01 INSTALLATION – GENERAL REQUIREMENTS

- A. Piping shall be insulated where shown or specified on the Drawings or where required to (1) prevent freezing, (2) protect people and building surfaces from injurious temperatures, and (3) prevent condensation in finished building areas. In general, and unless otherwise specified, insulation shall be required on the following piping:
 1. Steam supply and condensate piping.
 2. Hot water piping.
 3. All piping within 8 feet of finished floor or working surface with a normal surface temperature exceeding 120°F.
 4. Exposed cold water piping located outside or in unheated building areas or crawl spaces.
 5. Cold water piping located in exterior masonry walls.
 6. Cold water piping located in finished building areas including offices, laboratories, break rooms, toilets corridors, control rooms, conference rooms, lobbies, and spaces above suspended ceilings, where condensate on piping would be undesirable.
 7. Air conditioning refrigerant piping.
 8. Roof drain piping located above suspended.
 9. Chemical piping located outside or in exterior trenches.
- B. Where piping is specified to be insulated, insulation shall be applied to all valves, fittings, and other appurtenances installed in the piping.
- C. Insulation shall be applied in such a way so as not to interfere with the normal operation of any valve, control, or other device.
 1. On items requiring removal for normal maintenance, insulation shall be installed so that maintenance can be performed without damaging insulation or vapor seal.
- D. Insulation shall be installed in accordance with the manufacturer's written instructions and recommendations using approved materials.
- E. Exterior of pipe shall be thoroughly clean and dry before insulation is installed. Mastics and adhesives shall be applied within the temperature range recommended by the manufacturer.
- F. Insulated piping shall be identified using color-coded plastic arrows, bands, and lettering, located and sized in accordance with requirements of the section entitled "Painting" of these Specifications.
- G. Insulation shall not be installed until all pressure testing is complete.

3.02 INSTALLATION OF FIBERGLASS INSULATION

- A. Layers of insulation shall be installed with horizontal longitudinal joints and held in place with aluminum bands. Care shall be taken when installing bands so as not to puncture vapor barrier. Longitudinal butt joints on multilayer insulation shall be staggered. Ends shall be butted tightly together. Longitudinal flaps on factory-applied vapor barrier jackets shall be

located at the 3 o'clock and 9 o'clock positions. Flaps shall be sealed with vapor barrier adhesive.

- B. After installation, all joints, holes, seams, etc., in the outer surface of the insulation shall be sealed with 3-inch-wide glass cloth tape embedded between layers of white vapor seal mastic. Ends of pipe insulation at valves, unions, fittings, and terminations shall be sealed with glass cloth embedded between layers of white vapor seal mastic. Vapor seal shall overlap pipe insulation at least 3 inches. On cold piping (carrying fluids at 70° F or below), provide intermediate vapor barrier seals at intervals of 21 feet. Minimum dry film thickness of vapor barrier shall be 1/16 inch.
- C. Aluminum protective jackets shall be installed so as to shed rainwater. Longitudinal seams in horizontal piping shall be located with the overlap at the 4 o'clock position. Girth seam overlaps shall be sealed with an approved sealant. Adjacent longitudinal seams shall be installed in alternate four o'clock positions.
- D. On hot piping (carrying fluids above 70° F), a contoured, galvanized steel protection saddle with welded interior leg shall be provided at hangers and supports for protection of insulation. Protection saddles shall be Grinnell Figure 160 or 161, Fee and Mason Figure 171 or 1710, or equal.
- E. On cold piping (carrying fluids at 70° F or below), a minimum 18 gauge galvanized steel insulation shield with a 180-degree contour shall be used to protect the insulation conforming to ASTM C533, Type 1, shall be provided under the pipe at all supports and hangers. Unless otherwise shown on the drawings, insulation shield shall be Grinnell Figure 167, Fee and Mason Figure 81, or equal.
- F. Where insulated piping passes through building walls, a galvanized steel sleeve shall be provided in the wall. Ends of sleeve shall be flush with wall surfaces.
- G. Contraction joints shall be provided in all straight sections of pipe insulation exceeding 6 feet in length. One joint shall be provided in section 6 to 12 feet for sections longer than 12 feet. Insulated flanged joints shall be considered contraction joints.
- H. Voids between valves, fittings, or flanges and the outer layer of insulation shall be packed with loose, low-density (1pcf), glass fiber insulation.

3.03 INSULATION OF ELASTOMERIC PIPE INSULATION

- A. Pipe insulation shall be cut to length and slipped over straight portions of piping.
- B. At fittings and valves, insulation shall be slit longitudinally and mitered or nested for proper fit. All joints shall be butted together tightly and sealed with approved adhesive. Insulation shall be banded until adhesive sets up.
- C. Insulation exposed to the weather shall be furnished with 2 coats of a flexible weatherproof finish.

END OF SECTION

SECTION 40 70 00

INSTRUMENTATION DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Primary elements.
- B. Transmitters.
- C. Receivers.
- D. Analytical instruments.
- E. Devices.
- F. Cables.

1.2 SYSTEM DESCRIPTION

- A. System consists of all field and panel mounted instrumentation devices as noted, complete with all necessary signal converters, isolators, amplifiers, power supplies, cables and other appurtenances necessary for interfacing with other components.
- B. Except as noted, scale all indicators in engineering units.

1.3 SUBMITTALS

- A. Submit product data.

1.4 MAINTENANCE AND TEST EQUIPMENT

- A. In addition to the tools and test equipment, provide the following complete with carrying cases, patch cords, etc.
 - 1. One portable admittance tester with rechargeable batteries as manufactured by Drexelbrook or equal, to calibrate the admittance instruments provided.
 - 2. One pneumatic calibrator as manufactured by Wallace & Tiernan, Meriam Instrument, or equal.
 - 3. One (1) hand held smart transmitter calibrators shall be provided by the transmitter manufacturer to calibrate all smart field transmitters provided.
- B. Spare Parts
 - 1. Miscellaneous Spare Parts
 - a. One year supply of items recommended by the Manufacturer of the equipment for each component.
 - 2. The spares shall be packed in a manner suitable for long-term storage and shall be adequately protected against corrosion, humidity and temperature.
 - 3. Provide other spare parts as indicated on the individual device specifications.

PART 2 - PRODUCTS

2.1 INSTRUMENTS AND DEVICES

A. Level Transmitters (Flow Measurements) – Ultrasonic

1. Type: Microprocessor based ultrasonic level transmitter. Unit shall have input or output filter capability.
2. Sensor: Sensors shall have minimum 26 foot range and shall be supplied with sufficient cable length for arrangement indicated. Sensor shall have a NEMA 4X (minimum) enclosure. Unit shall be supplied with automatic temperature compensation as required below. Sensor face material shall be Kynar or Teflon as required.
3. Accuracy: ± 1.0 percent of calibrated range or better for ranges greater than 25-inches (with temperature compensation).
4. Output: Isolated 4-20 mA DC into loop loads of 0 to 500 ohms (minimum), two (2) Form "C" Relay Contacts rated at 5A, 250 VAC, non-inductive.
5. Enclosure: NEMA 4X, polycarbonate or fiberglass.
6. Power Supply: 120 VAC
7. Mounting: The System Manufacturer shall coordinate mounting to ensure that the sensor is mounted away from vessel walls and other obstructions in accordance with the manufacturer's recommendations. All chemical storage tank sensors shall have Teflon face suitable for 4" flange mounting. The System Manufacturer shall provide appropriate standoff distance for sensor face from the highest liquid level to accommodate blanking distance.
8. Acceptable Manufacturers: Equal to Milltronics (Hydro-Ranger 200), Endress & Hauser (Prosonic), Systematic Controls, or STI.

B. Level Transmitter (Submersible Head-Type)

1. Type: Pressure sensor
2. Transmitter: Control box with Local LED display of level in Feet and built-in power supply to convert 110/1/60 to 24 VDC for pressure sensor loop power. Control box to have one or two displays as required.
 - a. Outputs: one or two 4-20 mA outputs
 - b. Accuracy: 0.3% of full range
 - c. Enclosure: NEMA 4X, polycarbonate housing
 - d. Power Supply: 120VAC, 1 PH, 60 HZ
3. Sensor: 316SS sensor housing and pressure sensor diaphragm with 33' of viton cable. Polarity independent leads for 24 VDC powered loop from transmitter. Atmospheric compensation tube built into cable. Range as specified on instrument chart.
4. Cleaning: Not required
5. Transmitter (Control Box) Mounting: mounted to 1/8" aluminum mounting plate with drip lid and SS hinged opaque sun shield.
6. Sensor Mountings:

- a. PVC hanger with minimum of 4" of cable contact and SS cable for hanging to eye bolt on side of tank or as specified on instrument chart.
- b. Slide Rail Mounting: Sensor supplied with two SS clips and 19" long SS Slide rail for wall mounting
7. Start-Up: provide minimum of 2 hours/meter of service by factory-authorized representative for system start-up plus ½ day of training.
8. Acceptable Manufacturer: Endress & Hauser Waterpilot FMX 21 model or approved equal.

C. Level Switch (Float Type)

1. Type: Submersible coated 316 stainless steel, polypropylene, or polyethylene body; non-mercury switch contact rated 4 amps at 120 VAC; normally open, normally closed, or Form C (N.O. and N.C.) contact configuration as indicated. Mercury float switches are unacceptable.
2. Cable: Minimum 18 gauge, 300 volt (minimum) rated; heavy-duty type SOW or equivalent. Provide sufficient length for mounting at the elevations indicated.
3. Junction Box: Provide NEMA 4X stainless steel junction box, mounted near the switch, for terminating vendor supplied cable and discrete control wiring to control panel.
4. Switch Mounting: The System Manufacturer shall provide 3/4 or 1 inch Schedule 40 PVC, 316 stainless steel pipe, or 1.25 inch cable for mounting the floats for a particular tank or well. The pipe shall extend from two feet above the highest switch setting (up to the top of the vessel) to two feet below the lowest level setting (down to the vessel bottom) for the vessel or well and allow for adjustment of the switch or switches anywhere along the length of the pipe. The method for fixing the float to the pipe shall be easily adjustable and shall provide for protection and strain relief for the float switch cable. Provide a minimum of two mounting brackets for fixing the pipe to the vessel wall while maintaining appropriate standoff distance. The System Manufacturer shall ensure mounting is in accordance with the manufacturer's recommendations.
5. Spare Parts: Provide 2 spare float switches.
6. Acceptable Manufacturers: Equal to Warrick Series M, Anchor Scientific.

D. Pressure and Vacuum Gauges

1. General: Pressure and vacuum gauges shall, unless otherwise specified, conform to the following. Gauges shall be of the stem-mounting type unless panel-mounted type is shown on the Schedule. Refer to Section 15100 – Valves, for additional requirements.
2. Construction: Gauges shall be of the bourdon tube or bellows type with 270 degrees clockwise pointer travel. Dials shall be white with black numerals. Dial size shall be 4 1/2-inch. Panel-mounted gauges shall have round bezels for flush mounting and rear connection, others shall have a stem-mounting bottom connection. Connections for all gauges shall be male 1/2-inch NPT with square wrench flats. Wetted parts shall be corrosion-resistant to the process fluid shown in the Table A and unless specified in the Table A shall be the manufacturer's best quality standard. All dials shall be glycerin filled, hermetically sealed. Cases shall be black phenolic. Accuracy shall be ±0.5% of span.
3. Chemical Seal: Where used for sewage or sludge service, the gauge shall be furnished with a diaphragm seal unless specified elsewhere. Diaphragm seals shall consist of bottom housing, lower ring, diaphragm capsule, fill screw, flushing connection, and a top housing. The diaphragm seal shall attach to the inlet connection of a pressure instrument to isolate its

measuring element from the process fluid. The space between the diaphragm and the instruments pressure element shall be completely filled with a suitable fill liquid – defaulting to silicone oil. Displacement of the liquid fill in the pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch or any other pressure instrument. The diaphragm seal shall have a removable bottom housing to permit the servicing of the need to refill. All exposed surfaces, top and bottom housings, and diaphragm shall be constructed of Type 316 stainless steel as a minimum and shall be compatible with the process fluid. The process connection shall be a 3/4-inch threaded connection with a flushing connection.

4. Manufacturers: The gauges shall be as manufactured by Ashcroft Duraguage, U.S. Gauge, or user approved equal. The diaphragm seals shall be as manufactured by Ashcroft 200 series, Mansfield and Green SG Series, or approved equal.

E. In-Line Pressure Seal

1. Where specified provide a pressure isolating ring that uses a elastomer membrane to isolate a pressure measurement from the process fluid in the pipeline. The membrane/diaphragm shall be provide direct contact with the process fluid but shall isolate the pressure measurement from the effects of solids, abrasives and slurries in the pipe line that would clog standard pressure sensing lines.
2. The pressure sensed by the membrane shall be transmitted to the associated pressure sensor, gauges, and/or transmitter via use of a suitable fill fluid – defaulting to silicone oil. Any air between the membrane and the associated pressure devices shall be fully evacuated during the filling process.
3. Inside diameter of the measuring membrane shall match the inside diameter of the associated pipeline.
4. Manufacturers: The in-line pressure seal shall be manufactured by Onxy Valve, Red Valve, or approved equal.

2.2 CABLES

A. Fiber Optic Cable

1. Fiber optic cable shall be optic multimode, loose tube, all-dielectric cable, Siemens, Nordx/CDT, Belden, or approved equal, and meet the following specifications:

Cladding Diameter	125.0 Microns
Core Diameter	62.5 Microns
Attenuation Range	≤0.8 dB/KM at 1300 NM ≤3.1 dB/KM at 850 NM
Bandwidth Range	≥600 Mhz-KM at 1300 NM ≥200 Mhz at 850 NM
Cable Construction	Splitable outdoor cable
Core Type	Hollow core, filled
Materials	
– basic element	PVC, gray
– strain relief	Kevlar fibers and impregnated glass

- outer sheath/cable color PVC black

Mechanical Characteristics

- dimensions of basic element (3.5 ± 0.2) mm dia
- cable dimensions (6.3 X 9.8) ± 0.4 mm
- cable weight approx. 65 kg/km
- permissible tensile load ≤ 500 N (short time)
- bending radii ≥ 100 mm Over flat side only

Permissible Ambient Conditions

- laying and installation temp. -5°C to +50°C
- operating temperature -25°C to +60°C
- storage temperature -25°C to +70°C

Cable shall be compliant with EIA, ANSI Standards, graded index. All fibers must be color coded for easy identification with all-dielectric construction. All cables shall be of an insulation type rated for the purpose of installation. Where shown on Contract Drawings all fiber optic conduit run shall contain redundant 24 strand fiber optic cables as specified in this section.

2. Connector Type BFOC
3. Coordinate the exact fiber cable requirement with the SCADA system integrator.

B. Industrial Twisted Pair (ITP) 100 Mb Fast Ethernet Cables

1. ITP cable shall have two cores stranded with two dummy elements to form a pair.
2. Each pair shall be sheathed in plastic film and shielded with two plastic-clad aluminum foils.
3. The outer shield braid shall be made of tinned copper wires around all pairs.
4. The plastic sheath shall be PVC.
5. The ITP cable shall be a standard 9 pin cable with RJ45 type connectors.
6. ITP Cables shall be Siemens Industrial Twisted Pair standard cable or equal by AT&T or Belden.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Instrument Tagging

1. Provide stainless steel identification tags attached with stainless steel wire or screws for all field instruments.

3.2 FIELD QUALITY CONTROL

A. Tests And Calibration

1. Perform continuity and insulation resistance tests on instrumentation conductors.

2. Calibrate each instrument to its published accuracy. Submit calibration sheets including the instrument tag number or name, the date, name of individual performing calibration, procedures and equipment used, and results obtained.

END OF SECTION

SECTION 40 70 01
METERS AND GAUGES

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following meters and gages for mechanical systems:
 - 1. Thermometers.
 - 2. Gages.
 - 3. Test plugs.
 - 4. Flowmeters.

1.02 SUBMITTALS

- A. Product Data: For each type of product indicated; include performance curves.
- B. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 THERMOMETERS

- 1. Case: Plastic, 7 inches (178 mm) long.
- 2. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.
- 3. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- 4. Window: Glass or plastic.
- 5. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- 6. Stem: Metal, for thermowell installation and of length to suit installation.
- 7. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

B. Duct-Type, Liquid-in-Glass Thermometers:

1. Case: Metal or plastic, 7 inches (178 mm) long.
2. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.
3. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
4. Window: Glass or plastic.
5. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
6. Stem: Metal, for installation in mounting bracket and of length to suit installation.
7. Mounting Bracket: Flanged fitting for attachment to duct and made to hold thermometer stem.
8. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

C. Bimetallic-Actuated Dial Thermometers:

1. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.
2. Case: Liquid-filled type, stainless steel with 3-inch (76-mm) diameter.
3. Element: Bimetal coil.
4. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
5. Pointer: Red metal.
6. Window: Plastic.
7. Ring: Stainless steel.
8. Connector: Adjustable angle type.
9. Stem: Metal, for thermowell installation and of length to suit installation.
10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

D. Thermowells:

1. Manufacturers: Same as manufacturer of thermometer being used.
2. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.03 PRESSURE GAGES

A. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Dry type, metal or plastic, 4-1/2-inch (114-mm) diameter.

2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
 3. Pressure Connection: Brass, NPS 1/4 (DN 8), bottom-outlet type unless back-outlet type is indicated.
 4. Movement: Mechanical, with link to pressure element and connection to pointer.
 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 6. Pointer: Red metal.
 7. Window: Glass or plastic.
 8. Ring: Metal or plastic.
 9. Accuracy: Grade B, plus or minus 2 percent of middle half scale.
 10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure (100 kPa of vacuum to 103 kPa of pressure).
 11. Range for Fluids under Pressure: Two times operating pressure.
- B. Pressure-Gage Fittings:
1. Valves: NPS 1/4 (DN 8) brass or stainless-steel needle type.
 2. Syphons: NPS 1/4 (DN 8) coil of brass tubing with threaded ends.
 3. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.04 TEST PLUGS

- A. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.
- B. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
- C. Core Inserts: One or two self-sealing rubber valves.
 1. Insert material for air, water, oil, or gas service at 20 to 200 deg F (minus 7 to plus 93 deg C) shall be CR.
 2. Insert material for air or water service at minus 30 to plus 275 deg F (minus 35 to plus 136 deg C) shall be EPDM.
- D. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
 1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be 0 to 200 psig (0 to 1380 kPa).
 2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F (minus 4 to plus 52 deg C).

2.05 FLOWMETERS

A. Wafer-Orifice Flowmeters:

1. Description: Differential-pressure-design orifice insert for installation between pipe flanges; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.
2. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
3. Pressure Rating: 300 psig (2070 kPa).
4. Temperature Rating: 250 deg F (121 deg C).
5. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.
6. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (150-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
 - a. Scale: Gallons per minute (Liters per second).
 - b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of range.
7. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot (3.7-m) hoses in carrying case.
 - a. Scale: Gallons per minute (Liters per second).
 - b. Accuracy: Plus or minus 2 percent between 20 and 80 percent of range.
8. Operating Instructions: Include complete instructions with each flowmeter.

B. Pitot-Tube Flowmeters:

1. Description: Insertion-type, differential-pressure design for inserting probe into piping and measuring flow directly in gallons per minute (liters per second).
2. Construction: Stainless-steel probe of length to span inside of pipe; with integral transmitter and direct-reading scale.
3. Pressure Rating: 150 psig (1035 kPa) minimum.
4. Temperature Rating: 250 deg F (121 deg C) minimum.
5. Display: Visual instantaneous rate of flow, with register to indicate total volume in gallons (liters).
6. Integral Transformer: For low-voltage power connection.
7. Accuracy: Plus or minus 1 percent for liquids and gases.

C. Flow Indicators:

1. Description: Instrument for installation in piping systems for visual verification of flow.

2. Construction: Bronze or stainless-steel body; with sight glass and plastic pelton-wheel indicator, and threaded or flanged ends.
 3. Pressure Rating: 125 psig (860 kPa).
 4. Temperature Rating: 200 deg F (93 deg C).
 5. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 6. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.
- D. Ultrasonic Flow Sensor
1. Description: Non-contact flow sensor, applicable to multiple flumes and weirs, measuring pH and flow in various units.
 2. Construction: NEMA 6P (IP68) polybutylene terephthalate (PBT) body with integral.
 3. Temperature Rating: -20 °C to 60 °C (-4 °F to 140 °F)
 4. Display: Transreflective display, 240 x 160 pixels.
 5. Accuracy: Plus or minus 0.5 percent of span.

PART 3 - EXECUTION

3.01 THERMOMETER APPLICATIONS

- A. Install thermometers in the following locations:
1. Inlet and outlet of each hydronic zone.
 2. Inlet and outlet of each hydronic boiler and chiller.
 3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
 4. Inlet and outlet of each hydronic heat exchanger.
 5. Inlet and outlet of each hydronic heat-recovery unit.
 6. Inlet and outlet of each thermal storage tank.
 7. Outside-air, return-air, and mixed-air ducts.
- B. Provide the following temperature ranges for thermometers:
1. Domestic Potable Hot Water: 30 to 180 deg F, with 2-degree scale divisions (Minus 1 to plus 82 deg C, with 1-degree scale divisions).
 2. Domestic Potable Cold Water: 0 to 100 deg F, with 2-degree scale divisions (Minus 18 to plus 38 deg C, with 1-degree scale divisions).

3.02 GAGE APPLICATIONS

- A. Install pressure gages for discharge of each pressure-reducing valve.
- B. Install pressure gages at chilled- and condenser-water inlets and outlets of chillers.
- C. Install pressure gages at suction and discharge of each pump.

3.03 INSTALLATIONS

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.
- C. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid and in vertical position in piping tees where thermometers are indicated.
- D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.
- E. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- F. Install remote-mounting pressure gages on panel.
- G. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).
- H. Install needle-valve and syphon fitting in piping for each pressure gage for steam.
- I. Install test plugs in tees in piping.
- J. Install flow indicators, in accessible positions for easy viewing, in piping systems.
- K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.
- L. Install flowmeter elements in accessible positions in piping systems.
- M. Install differential-pressure-type flowmeter elements with at least minimum straight lengths of pipe upstream and downstream from element as prescribed by manufacturer's written instructions.
- N. Install wafer-orifice flowmeter elements between pipe flanges.
- O. Install permanent indicators on walls or brackets in accessible and readable positions.
- P. Install connection fittings for attachment to portable indicators in accessible locations.
- Q. Install flowmeters at discharge of hydronic system pumps and at inlet of hydronic air coils.
- R. Mount meters on wall if accessible; if not, provide brackets to support meters.
- S. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.
- T. Calibrate meters according to manufacturer's written instructions, after installation.
- U. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION

SECTION 40 90 00

INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.01 SCOPE

A. Requirements

Requirements specified in Division 01 of these Specifications form a part of Division 26. This Section covers the general requirements for furnishing and installation of the instrumentation, control and monitoring (ICM) system complete in every detail for the purposes specified and shall form a part of the other Sections of Division 26 unless otherwise specified. The other Sections of this Division shall supplement this Section as necessary.

1. Work Included

- a. The intent of Division 40 is to require that the complete Instrumentation, Control and Monitoring System, including other Sections of Division 40 shall be furnished by a single Control Systems Integrator (CSI) to assure system uniformity, subsystem compatibility and coordination of system interfaces.
 - b. The new SCADA system shall deliver a complete and functional system as described herein, as per the Contract Documents, and as shown on the Contract Drawings. The SCADA system shall be capable of monitoring and performing controls (as indicated on the drawings) of Homesteads Pollution Control Facility equipment. And shall be capable of communication with the existing Piedmont Water master SCADA workstation to depict the new facility I/O points and new HMI graphics. All equipment, materials, incidentals, software, supervision, and labor shall be provided under this Contract.
 - c. Furnish the tools, equipment, materials, and supplies and perform the labor required to complete the furnishing and installation of, including instrumentation signal and power conduit and wiring not specifically shown on the electrical drawings, validation, start-up and operational testing of a complete and operable ICM system as indicated on the Contract Drawings and as specified herein.
 - d. Provide the equipment components, interconnections and the services of the manufacturers' engineering representatives for the engineering, implementation, startup, operation, and instruction, to ensure that the Owner receives an integrated and operational ICM system as herein specified.
 - e. Coordinate with the requirements of Division 26 – Electrical, and provide for operator restart of all equipment on restoration of loss-of-power condition. Sequence automatically equipment restart and provide for time delays as necessary to prevent breaker trips on inrush from multiple equipment concurrent starting.
2. As a minimum, the CSI shall perform the following work:
 - a. Implementation of the ICM system:
 - i. Prepare shop drawing submittals.

- ii. Design, develop, and electronically draft loop drawings and control panel designs.
 - iii. Prepare the test plan, the training plan, and the spare parts submittals.
 - iv. Procure hardware.
 - v. Fabricate panels.
 - vi. Program the ICM system as shown on the Contract Drawings.
 - vii. Perform factory tests on panels.
 - viii. Perform bench calibration and verify calibration after installation.
 - ix. Oversee and certify installation.
 - x. Oversee, document, and certify loop testing.
 - xi. Oversee, document, and certify system commissioning.
 - xii. Conduct the performance test.
 - xiii. Prepare operations and maintenance manuals.
 - xiv. Conduct training classes.
 - xv. Prepare record drawings.
 - xvi. Prepare calibration sheets.
 - xvii. Certify the installation of the ICM system.
 - b. Integration of the ICM system with instrumentation and control devices being provided under other Sections:
 - i. Develop all requisite loop drawings and record loop drawings associated with equipment provided under other Divisions and Owner equipment.
 - ii. Resolve signal, power, or functional incompatibilities between the ICM system and interfacing devices.
3. Work Not Included
- a. Process piping, installation of in-line instrumentation, i.e., final control elements in process pipelines, air compressors, main air supply headers, and mechanical work as specified in other Divisions.
 - b. Electrical power distribution specifically included under Division 26, circuit protection devices, power conduit and wiring indicated, local equipment control stations, and miscellaneous electrical requirements as specified in Division 26.

B. System Responsibility

- 1. The ICM system as specified in Division 40 is an integrated system and therefore shall be provided by a competent, qualified CSI who shall have total responsibility for the Work of Division 40. Entire system installation including calibration, validation, start-up, operational testing, and training shall be performed by qualified personnel, possessing all the necessary equipment and who have had experience performing similar installations. The System shall be integrated using the CSI's latest, most modern proven design and shall, as far as practical, be by one manufacturer.
- 2. The Contractor shall perform the Work under this Division 40, through the use of a qualified CSI who shall perform said Work but it shall be understood that this shall not relieve the Contractor from any responsibility under the Contract.

3. The Contractor shall be responsible for the correct installation of all hardware and systems specified in Division 40.
4. The Contractor shall be responsible to see that all instrumentation components of other Divisions, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling, alarming devices and appurtenances are compatible and shall function as outlined, and he shall furnish and install such additional equipment, accessories and appurtenances as are necessary to meet these objectives at no additional cost to the Owner.
5. The Contractor shall use the instrument tag and equipment numbering scheme as shown in Contract Documents, for identifying components which are part of this system.
6. Due to the complexities associated with the interfacing of numerous control system devices, the CSI or vendor shall be responsible to the Contractor for the integration of the ICM system with existing devices and devices provided under other Divisions and provide a completely-integrated control system free of signal incompatibilities; this includes providing review and comment to other vendor equipment submittals and overall coordination of the system.

C. Certification of Intent:

1. Fifteen days after notice to proceed, the Contractor shall submit a certification from the selected CSI. The certification shall be typed on letterhead paper of the CSI. The certification shall be signed by an authorized representative of the CSI. The certification shall include the following statements:
 - a. (Company name) "hereby certifies intent to assume and execute full responsibility to the Contractor to perform all tasks defined under Paragraph 1.01 Scope, in full compliance with the requirements of the Contract Documents."
 - b. "It is certified that the quotation to the Contractor includes full and complete compliance with the requirements of the Contract Documents without exception."

D. Documentation of Instrumentation Subcontractor Qualifications:

1. General
 - a. The entire control system installation including panel building, calibration, validation, start-up, operational testing, and training shall be performed by a control systems integrator (CSI) staffed with qualified personnel, possessing necessary equipment and experience in performing similar installations.
 - b. The system shall be integrated using the latest, most modern proven design and shall, as far as practical, be of one manufacturer.
 - c. The equipment, level of detail, and overall quality of the control system shall be consistent a typical industrial type control system.
 - d. Overall system performance shall be guaranteed.
 - e. Software packages shall be latest versions available.
2. System Integrator qualifications:
 - a. The following system integrators are pre-qualified to perform the control system work described in Division 40:

- i. **Southern Flow Inc., Alpharetta, GA**
- ii. **MR Systems (Inframark), Norcross, GA.**

3. Training and Certification:

- a. Completion of the following training courses (or appropriate portions thereof) or possession of the following certifications may be substituted for portions of the System Integrator's personnel experience requirements described above.
- b. Project manager: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or completion of the relevant core courses in the Engineering Skills Training program.
- c. Systems engineer: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or completion of the relevant core courses in the Engineering Skills Training program.
- d. Programmer: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or completion of the relevant core courses in the Technical Skills Training program.
- e. Field instrument technician: Certified Control Systems Technician (CCST) registration or completion of the relevant core courses in the Technical Skills Training program.
- f. Training program curriculums as offered by ISA.
- g. Training or certification does not satisfy the related project experience requirements described above.
- h. Submit training and registration evidence with the above experience evidence.

E. Contract Drawings

1. Information on the Drawings

- a. The following information relative to the Work of Division 40 is indicated on the Division 26 Contract Drawings.
 - i. Location of primary elements, control panels, and final control elements.
 - ii. Instrumentation signal and power conduit runs between control panels and field instruments and devices.
 - iii. Quantity and sizes of instrumentation conductors and cables are indicated on the drawings, but shall be verified by the Contractor.
 - iv. Location of all equipment having alarm and equipment status contacts.
 - v. Major instrument conduit runs.

2. Information Not on the Drawings

- a. The following information relative to the Work of Division 40 may not be shown on the Drawings, but shall be the responsibility of the Contractor to determine, furnish, coordinate with other Trades, and submit for acceptance, based upon the systems specified.
 - i. Tubing for pneumatic signals, and/or power between main headers and control panels, field mounted primary elements, field instruments and final control elements.
 - ii. Number or sizes of tubing required for pneumatic and hydraulic signals.

- iii. Point of connection to any hydraulic or pneumatic supply lines.

1.02 REFERENCES

- A. Publications listed below form a part of this Section to the extent referenced. The publications are referred to in the text by basic designations only.
 - 1. Instrument Society of American (ISA).
 - a. ISA S5.4 – Instrument Loop Diagrams.
 - 2. National Electrical Manufacturers Associations (NEMA).
 - a. NEMA – Electrical Code.
 - 3. American Standard Code for Information Interchange (ASCII).
 - 4. Institute of Electrical and Electronic Engineers (IEEE).
 - a. IEEE C62.41 – Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits.

1.03 SUBMITTALS

A. General.

Refer to the General Conditions of the Contract Documents for required method of preparation and transmittal and conform to requirements herein.

- 1. Pre-submittal Conference
 - a. Arrange a conference with CSI, the Engineer, and the Owner within thirty (30) days after award of the Contract for the purpose of informally discussing in detail and verifying the correctness of the CSI's system engineering methods and equipment and to generally provide a framework for communication and coordination. This conference shall be attended by CSI, and duly authorized representatives of the Contractor, Engineer, and Owner.
 - b. Submit 4 copies of the following items for discussion at the Pre-submittal Conference:
 - i. A list of equipment and materials required for the ICM system and the manufacturer's name and model number for each proposed item. Identify items by tag number, description, function, manufacturer, model number, descriptive literature and statement as to whether item is "as specified" or "equivalent." Items identified as "equivalent" shall be accompanied by a comparative listing of the published specifications for the item specified and for the item proposed. Equivalent items shall only be accepted by the Engineer if the specified item is no longer manufactured.
 - ii. A list of proposed clarifications to the Contract Documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the Engineer.
 - iii. A sample of each type of submittal specified herein.
 - iv. A flow chart showing the steps to be taken in preparing and coordinating each submittal.
 - v. A bar-chart type schedule for all system related activities from the Pre-submittal Conference through start-up and training. Dates of submittals,

design fabrication, programming, factory testing, deliveries, installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.

- vi. An overview of the proposed training plan. The Engineer will review the overview and may request changes. All changes to the proposed training shall be resolved at the Pre-submittal Conference. The overview shall include the following for each proposed course:
 - a) Course title and objectives.
 - b) Prerequisite training and experience of attendees.
 - c) Course content – a topical outline.
 - d) Course duration.
 - e) Course format – lecture, laboratory demonstration, etc.
- vii. A preliminary copy of the ICSI Qualification submittal.
- c. Take minutes of the Pre-submittal Conference, including all events, questions, and resolutions. Before adjournment, all parties must concur with the accuracy of the minutes and sign accordingly.

B. Shop Drawings

Before proceeding with any manufacturing, submit Shop Drawings for acceptance in complete bound sets indexed by specification number. Describe the items being submitted. Manufacturer's specification or data sheets shall be clearly marked to delineate the options or styles to be furnished. Submit only complete systems, not pieces of equipment from various systems. Show dimensions, physical configurations, methods of connecting instruments together, mounting details, and wiring schematics. Schematics shall be complete with tag and terminal numbers. Submit fabrication drawings, nameplate legends, and control panel internal wiring and piping schematic drawings clearly showing equipment and tag numbers on panels. Submit panel graphic drawings where applicable. Include material specifications lists where applicable. Include a draft of the theory of operation for relay logic circuits including those implemented via programmable controllers. Submit detailed field instrument installation drawings for each instrument.

C. Design Related Submittals

- 1. In accordance with the requirements of Section 01 - Submittals, provide the following submittals:
 - a. Catalog Cuts
 - i. Catalog information, descriptive literature, wiring diagrams, and shop drawings shall be provided for all devices, whether electrical or mechanical, furnished under Division 40. This includes, but is not limited to, primary elements, transmitters, analytical equipment, gauges, valves, controllers, indicators, power supplies, switches, lights, relays, timers, etc.
- 2. Component Data Sheets
 - a. Data sheets, specification sheets, and an instrument list shall be provided for components provided under this Section. The purpose of this material is to

supplement the generalized catalog information by providing the specifics of each component (e.g., part numbers, scales, ranges, service, materials of construction, component location, options, and the individual tag number as noted in the Contract Drawings and in Contract Documents.

- b. Include such other necessary data as would provide a complete and adequate specification for reordering an exact duplicate of the original item from the manufacturer at some future date. More than one tag numbered item may be included on a sheet.
- 3. Sizing Calculations
 - a. Complete sizing calculations shall be provided for all flow elements. The calculations shall include the process data used, minimum and maximum values, permanent head loss and all assumptions made. Equations shall be submitted for all computing modules and function generating modules and shall include the actual scaling factors and units used.
- 4. Panel Construction Drawings
 - a. Shop Drawings and Catalog Cuts
 - i. Provide detailed shop drawings and catalog cuts for panels, instrument racks, and enclosures. Drawings shall show the location of front panel and internal sub-panel mounted devices to scale and shall include a panel legend and bill of materials. Layout drawings shall show major dimensions as well as elevations, in inches from the base up, of the rows of components.
 - ii. Shop drawings shall indicate location and size of available spare mounting space for rear-of-panel devices.
 - iii. The panel legend shall list and identify front of panel devices by their assigned tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
 - iv. The bill of materials shall include devices mounted within the panel that are not listed in the panel legend, and shall include the device tag number, description, manufacturer, and complete model number.
 - b. Color Schedule
 - i. Provide a color schedule with color samples for control panels for the Owner's selection/approval.
- 5. Power Requirement and Heat Dissipation
 - a. Provide a summary of the power requirements and heat dissipation for control panels. Power requirements shall state required voltages, currents, and phase(s). Heat dissipations shall be maximums and shall be given in BTU/Hr. Summary shall be supplemented with calculations.
- 6. Panel Wiring Diagrams
 - a. Wiring diagrams shall be similar to those diagrams shown in the Contract Drawings, but with the addition of all auxiliary devices such as additional relays, alarms, fuses, lights, hand switches and interlocks.
 - b. Provide complete terminal identification of external primary elements, panels, and junction boxes that interface directly to the panel wiring being shown. Polarity of analog signals shall be shown at each terminal.

- c. External wiring that the electrical contractor must provide and wire shall be shown as a dotted line. Special cables that are provided with the instrument shall be clearly identified.
 - d. Panel wiring diagrams shall identify wire numbers and types, terminal numbers, and tag numbers. Wiring diagrams shall show each circuit individually. Common or typical diagrams shall not be allowed.
 - e. Provide panel power wiring diagrams for panels. The diagrams shall include grounding requirements.
7. Interconnecting Wiring Diagrams
- a. Diagrams shall show component and terminal board identification numbers, external wire and cable numbers. The drawings shall show intermediate terminations between field elements and panels (e.g., terminal junction boxes) This diagram shall be coordinated with the Contractor and shall bear his mark showing that this has been done.
8. Loop Diagrams
- a. Provide an individual wiring diagram for each analog loop showing terminal numbers, the location of the DC power supply, the location of any dropping resistors, the location and connection of the surge protection devices. The loop diagrams shall meet the minimum requirements of ISA S5.4 plus the following requirements:
 - b. Each loop diagram shall be divided into three areas for identification of device locations: panel face, back-of-panel, and field respectively. Each loop diagram shall list (1) Transmitter Drive Capability, (2) Loop Impedance, (3) Transmitter Reserve Drive Capability. Loop diagrams shall be on 11-inch by 17-inch Drawings.
9. Instrument Installation Details
- a. The CSI shall review the Contract Documents and develop and submit for review, complete installation details for each field mounted device and panel prior to shipment and installation. Common details, not requiring any modification, may be referenced by an index showing the complete instrument tag number, service, location, and device description. Installation details shall be provided as required to adequately define the installation of the ICM system components.
10. Operator Interface Submittal
- a. This submittal shall cover the specific plant control schemes as well as the details of the plant reports and process graphic displays.
 - b. The submittal shall contain the semi-final details of all logs, reports, and process graphic displays. The specifics of what shall appear on each display and what calculations are required to support them shall be developed and submitted.
 - c. Submitted process graphic displays shall be no smaller than 8.5-inches by 11-inches and in full color.
 - d. A complete listing of all signals to be collected for long term historical information shall be provided. This listing shall also include frequency of data sampling and duration for which the data shall be immediately accessible.

- e. A complete listing of all signals to be collected for trend display shall be provided. This listing shall also include frequency of data sampling and duration for which the data shall be immediately accessible.
11. Process Control Strategy Submittal:
- a. The process control schemes shall be developed in a ladder logic diagram or functional block (logic) diagram presentation based on information from the Contract Documents. Included with each diagram shall be:
 - i. Brief Scope of the Control Function.
 - ii. Listing of all scanned inputs to the control function.
 - iii. A short narrative of the control strategy.
 - iv. Any assumptions made in developing the program.
 - v. Listing of all inputs and outputs (i.e., AI, DI, AO, DO) from the control function.
 - vi. Cross reference list of all I/O showing to which I/O modules or software modules they are linked.
 - vii. Listing of all operator inputs/outputs to and from the control function. Any special CRT displays related to the function shall be illustrated. A description of the operation of any panels shall be described as it relates to the control function.
 - viii. Failure contingencies shall be described in detail.
 - ix. A flowchart representing the control strategy.
 - b. This submittal shall cover all of the associated logic developed under the CSI required to implement the control functions specified.
 - c. The System Integrator shall submit annotated logic on 8-1/2-inch x 11-inch format and as an ASCII file on compact diskettes for all logic developed. Annotation shall be 3 lines of 6 characters each for every logic contact. In addition, each network or rung shall be annotated so that a non-technical person can read and easily comprehend what control function the rung or network is performing.
 - d. This submittal shall also include copies of the PLC I/O configuration tables, I/O reference usage table, complete cross reference to specific rung used of all inputs, outputs, internal coils, data registers, and special purpose coils. In addition, any special switch settings or hardware configuration requirements such as com port configurations shall be described in detail and submitted.

D. Test Related Submittals

Provide five (5) copies of the following:

1. Operational Field Acceptance Test (OAT) Documentation.

The CSI shall submit an example of each type of Instrument Calibration Sheet and Loop Status Report that will be used for the OAT.

After acceptance of the examples, the CSI shall prepare Loop Status Report Sheet(s) for each loop and an Instrument Calibration Sheet for each active ICM system element (except simple hand switches, lights, etc.) These sheets shall be submitted after the tests are completed.

- a. Instrument Calibration Sheets.
 - i. Provide a written report to the Engineer on each instrument certifying that it has been calibrated to its published specified accuracy. This report shall include all applicable data as listed below plus any defects noted, correction action required, and correction made. Data shall be recorded on prepared forms and shall include not less than the following items:
 - a) Facility identification (Name, location, etc.)
 - b) Loop identification (Name or function)
 - c) Equipment tag and serial numbers.
 - d) Scale Ranges and units.
 - e) Test mode or type of test.
 - f) Input values or settings.
 - g) Expected outputs and tolerances
 - h) Actual readings at 10%, 50%, and 90% of span.
 - i) Explanations or special notes as applicable.
 - j) Date, time, and weather.
 - k) Tester's certification with name and signature.

2. Functional Acceptance Test Documentation.

The CSI shall prepare two types of test procedures and forms as follows.

a. Loop Test Documentation

For functions that can be demonstrated on a loop-by-loop basis, the form shall include:

- i. Project Name.
- ii. Loop number.
- iii. Loop description.
- iv. Test procedure description, with a space after each specific test to facilitate sign off on completion of each test.
- v. For each component: tag number, description, manufacturer, and data sheet number.
- vi. Space for sign off and date by the CSI, the Contractor, and the Engineer.

b. Functional Test Documentation

For those functions that cannot be demonstrated on a loop-by-loop basis, the test form shall be a listing of the specific tests to be conducted. With each test description the following information shall be included:

- i. Specification page and paragraph of function demonstrated.
- ii. Description of Function.
- iii. Test procedure description.
- iv. Space after each specific test to facilitate signoff on completion of each test.

E. Testing

- 1. Factory Testing, field Testing, and Final Acceptance Testing shall be provided.
- 2. System Commissioning Assistance.

- a. Provide the services of a factory trained and field experienced instrumentation engineer to assist Owner's personnel during each startup of the various systems. Purpose of this assistance is to support in making final adjustments of settings on the instrument systems.

F. Operation & Maintenance Manuals.

Furnish Instruction Manuals and Parts Lists for instrumentation equipment in accordance with the requirements of Division 1 and as noted herein.

1. Schedule.
 - a. Deliver manuals not later than the equipment shipment date. After installation is complete, update the manuals to reflect any changes which occurred during installation and deliver balance of manuals to Engineer.
2. Material Content. Include in the manuals not less than the following applicable information for each instrument, equipment, subsystem and/or control loop. The O&M Manuals shall consist of, at least, the following material:
 - a. Bill of Materials.
 - i. A listing of all the panels, racks, instruments, components, and devices supplied. Components shall be grouped by component type, with the component types identified in a similar manner to the component identification code used in these specifications. The list shall contain, as a minimum:
 - a) Instrument, panel, rack or device tag number.
 - b) Description.
 - c) Quantity supplied.
 - d) Reference to component data sheet and/or catalog cut.
 - e) Component type.
 - b. Component Data Sheets.
 - i. See Paragraph 1.03 C.2 specified herein before.
 - c. Catalog Cuts.
 - i. See Paragraph 1.03 C specified herein before.
 - d. Component O&M Manuals.
 - i. An O&M manual shall be submitted for instruments and devices supplied. The O&M manuals shall contain, as a minimum:
 - a) Operating procedures.
 - b) Installation procedures.
 - c) Maintenance procedures.
 - d) Troubleshooting procedures.
 - e) Calibration procedures.
 - f) Internal device schematics and wiring diagrams.
 - g) Shut-down procedures.
 - h) Component parts list.

- i) Detailed circuit operational description including annotated programmable controller ladder diagrams.
- e. Spare Parts and Expendables List
 - i. The spare parts and expendables list shall include not only those items supplied, but also the additional items recommended for successful long term operation.
- f. "As-Shipped" Drawings
 - i. Drawings shall be a record of work "As-Shipped" from the factory and shall be labeled as "As-Shipped". One copy of applicable schematics and diagrams shall be placed in each control panel in a protective envelope or binder. Provide the following "As-Shipped" drawings as a minimum:
 - a) Panel Fabrication Drawings.
 - b) Panel Wiring and Interconnection Drawings.

G. Final Record Documentation's

1. Reproducible Drawings. Contractor shall submit reproducible's of finished schematics, wiring diagrams and installation drawings to include installed field and panel instruments, mounting details, point to point diagrams with a cable, wire, and termination numbers. Drawings shall be a record of work as actually constructed and shall be labeled as "RECORD DOCUMENTS", in accordance with the requirements of Section 01 – Contract Closeout. One copy of applicable schematics and diagrams shall be placed in each control panel in a protective envelope or binder.
 - a. Loop Diagrams.
 - 1) See Paragraph 1.03 C.8 specified herein before.
 - b. Panel Fabrication and Wiring diagrams.
 - 1) See Paragraph 1.03 C.4 and 1.03 C.6 specified herein before.
 - c. Interconnecting Wiring Diagrams.
 - 1) See Paragraph 1.03 C.7 specified herein before.
 - d. Instrument Installation Details.
 - 1) See Paragraph 1.03 C.9 herein before.
2. Process and Instrumentation Diagrams (P&ID's).
 - a. The Engineer will supply the Contractor with P&ID's for revisions to reflect the final installed system.
 - b. The P&ID's shall be updated by the Contractor who may use these drawings for producing the final documentation.
3. Software Documentation. In addition to the reproducible hard copy of drawings and literature generated specifically for the project, Contractor shall submit electronic copy to the Engineer with all custom files specifically created to generate the drawings, data sheets, bill of materials, operating procedures etc. Drawing format shall be compatible with AutoCad ver. 2022 or newer.

H. Training Requirements.

1. General:

- a. Contractor shall provide the services of a CSI factory trained and field experienced instrumentation engineer to conduct group training of Owner's designated personnel in the operation of each instrument system. Obtain Owner's written consent that the training has been adequate. Include instruction covering basic system theory, operating principles and adjustments, routine maintenance and repair, and "hands on" operation. The text for this training shall be the P & ID's, graphic operation interface, PLC and SCADA software, panel wiring diagrams and layouts, and the operation and maintenance manuals furnished under these Specifications.
- 2. Duration:
 - a. Training specific to the system control panel hardware and software. This training shall be for a minimum time period of 30-8-hour days and 6 trips. This training shall be separate from start-up and testing.
- 3. Operator Training:
 - a. Operator training shall include instruction in the use of Control Panels and Field Panels furnished.
- 4. Maintenance Training:
 - a. Maintenance training shall include instruction in the calibration, maintenance, and repair required for all instruments.
- I. Post-Contract System Support.
 - 1. Maintenance Contract:
 - a. Duration.
 - i. Provide a 1 year maintenance contract for components furnished starting from the date of acceptance with an option to extend the contract annually.
 - b. Schedule.
 - i. Develop a program of preventive maintenance visits that includes verification of instrument performance on a monthly basis and complete calibration of instruments on a semi-annual basis. After every visit, submit to the Owner records of instrument verification and calibration on appropriate forms.
- J. Guarantee and Warranties
 - 1. The equipment manufacturers shall warrant and guarantee against defective equipment, workmanship, and materials under normal use, operation and services, unless otherwise noted in other Division 40 Sections shall be for a period of 2 years after acceptance from the final date or final resolution of the Owner acceptance of Work as substantially complete. For equipment bearing a manufacturer's warranty in excess of two years, furnish a copy of the warranty to Engineer with Owner named as beneficiary.

PART 2 - PRODUCTS

2.01 HARDWARE REQUIREMENTS

A. Job Conditions.

1. Contract Drawings are diagrammatic and show the intended arrangement for system operation, piping, and appurtenances. Conform to Contract Drawings as closely as possible and exercise care (1) to secure neat arrangement of piping, valves, conduit, and like items, and (2) to accommodate structural features. Verify dimensions and conditions at the project site, and install materials and equipment in the available spaces.
- B. Materials and Standard Specifications.
1. Provide instruments, equipment and materials suitable for service conditions and meeting standard specifications such as Instrument Society of America (ISA). The intent of this Specification is to secure instruments and equipment of a uniform quality and manufacture throughout the facilities, instruments supplied by the Contractor, of the same type shall be by the same manufacturer. All panel mounted instruments shall have matching style and general appearance. All meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise required to match existing equipment. This allows the stocking of the minimum number of spare parts.
- C. Product Delivery, Storage, and Handling.
1. Box, crate, or otherwise enclose and protect instruments and equipment during shipment, handling, and storage. Keep all equipment dry and covered from exposure to weather, moisture, corrosive liquids and gases or any element which could degrade the equipment. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Repair any damage as directed and approved.
- D. Mountings.
1. Mount and install equipment as indicated. Where not shown, mount field instruments according to best standard practice on pipe mounts, pedestal mounts, or other similar means in accordance with suppliers recommendation. Unless specified otherwise all mounting hardware shall be stainless steel. Where mounted in control panels, mount according to manufacturer recommendations.
 2. Equipment specified for field mounting shall be suitable for direct pipe mounting, pedestal mounting, or surface mounting. Non in-line indicators and equipment with calibration adjustments or requiring periodic inspection shall be mounted not lower than three (3) feet nor higher than five (5) feet above walkways, platforms, and catwalks. Such equipment shall be weather and splash proof, and corrosion resistant and electrical equipment shall be in Type 316 stainless steel NEMA 4X cases unless otherwise noted.
- E. Instrument Identification.
1. Components provided under this Section, both field and panel mounted, shall be provided with permanently mounted name tags bearing the entire ISA tag number of the component. Panel mounted tags shall be plastic; field mounted tags shall be stamped stainless steel.
 2. Nameplates for panels and panel mounted equipment shall be as specified on the design documents.

3. Field mounted tags shall be 16-gauge, Type 304 stainless steel with 3/16-inch high characters.
4. Tags shall be attached to equipment with a commercial tag holder using a stainless steel band with a worm screw clamping device or by a holder fabricated with standard stainless steel hose clamps and meeting the same description. In some cases where this would be impractical, use 20 gage stainless steel wire.
5. For field panels or large equipment cases use stainless steel screws, however, such permanent attachment shall not be on an ordinarily replaceable part. In each case, the tag shall be plainly visible to a standing observer and not obscure adjustment ports or impair the function of the instrument. Field mounted control stations, recorders or indicators shall have a nameplate indicating their function and the variable controlled or displayed. Nameplate shall be attached by one of the above methods.

F. Electronic Equipment.

1. If the equipment is electronic in nature, provide solid state equipment to the greatest extent practicable. Select components of construction for their suitability and reliability. Employ adequate component derating to preclude failures because of transients and momentary overloads reasonably expected in normal operation. Where conduit connection is provided for mounting a surge/lightning suppresser directly to the instrument, the arrestor shall be so mounted. Field equipment shall have a Joslyn (or accepted equal) surge suppresser mounted on the instrument housing, if such mounting is provided on the instrument, otherwise a threaded surge suppresser connection shall be provided on the conduit as close as practical to the instrument. See Section 16473 – Low Voltage Surge Suppression Devices.

G. Equipment Operating Conditions.

1. Equipment shall be rated for normal operating performance with varying operating conditions over the following minimum ranges:
2. Power:
 - a. Electrical. 115 VAC +/- 10%, 60 Hz +/- 1 Hz except where specifically stated otherwise on the drawings or in the specifications.
3. Field Instruments:
 - a. Atmospheric contaminants (All Areas):
 - i. Hydrogen Sulfide: 0.1 mg/l.
 - ii. Chlorine: 0.01 mg/l.
 - iii. Ammonia: 0.5 mg/l.
 - iv. Dust: 50.0 µg/m³.
 - b. Outdoor Areas:
 - i. Ambient Temperature: -20°F to +120°F.
 - ii. Ambient Relative Humidity: 10% to 100%.
 - iii. Weather: Rain, wind, sun and blowing sand.
4. Indoor Environmentally Uncontrolled Areas:
 - a. Ambient Temperature: 40°F to +105°F.
 - b. Ambient Relative Humidity: 20% to 80%.

5. Indoor Environmentally Controlled Areas:
 - a. Ambient Temperature: 55°F to +85°F.
 - b. Ambient Relative Humidity: 20% to 80%.
 - c. Short term excursions to temperature limits for non-environmental controlled areas.
6. Provide, as necessary, enclosures, heat tracing, heaters and sunshields, etc. to assure normal operations under these conditions.
7. Corrosive Areas: Provide instrument enclosures and hardware suitable for the corrosive location.
8. Hazardous Areas: All equipment used in areas designated as hazardous shall be designed for the Class, Group, and Division as required on the Contract Drawings for the locations. All Work shall be in strict accordance with codes and local rulings, should any work be performed contrary to said rulings, ordinances and regulations, the Contractor shall bear full responsibility for such violations and assume all Owner costs arising there from.

H. Power Supplies.

1. Provide electrical instruments and control devices for operation on 120 VAC, 60 Hz current. Protect each device power supply with properly sized fuses.
2. Unless otherwise indicated provide battery backed up Uninterruptable Power Supply (UPS) with AC inversion for each control panel and PLC. UPS shall be sized to run the peak tributary load for a period of not less than 30 minutes. UPS shall be mounted in the respective panel. Minimum UPS size shall be 990 watt-hour. Provide bypass switch for panels to run directly from power source or through UPS with front of panel mounted indicator light showing current models.
3. Output overvoltage and overcurrent protective devices shall be provided for DC power supplies to protect instruments from damage due to power supply failure and to power supply from damage due to external failure. Power supplies shall be provided with NEMA 1 enclosures. Power supplies shall be mounted such that dissipated heat does not adversely affect other components. Source of operating power shall be 120 VAC, 60 Hz commercial power. Units shall be mounted within the control panels. Power supply fusing shall be provided with blown fuse indicators.

I. Signal Isolators, Converters and Conditioners.

1. Insure that input-output signals of all instruments and control devices (new and existing) are compatible. Analog signals between field and panels shall be 4-20 mA unless specifically accepted otherwise. Granting such acceptance does not relieve the Contractor from the compatibility requirement above. Provide signal isolators and converters as necessary to obtain the required system performance. Mount the devices behind control panels or in the field at point of application, as required for accurate signal acquisition.

J. Auxiliary Contacts by Others.

1. Provide instruments and equipment to connect to auxiliary contacts provided by others for alarms, status of equipment, interlocking, and other functions as indicated and as specified herein.

K. Painting.

1. Provide factory paint for instruments and equipment except where in pipelines.

L. Electrical.

1. Work shall include the power supply wiring, instrumentation wiring, interconnecting wiring and equipment grounding as indicated, specified and required and not specifically included under Division 26.
2. Wiring installations shall include cables, conductors, terminals, connectors, wire markers, conduits, conduit fittings, supports, hardware and all other required materials not specifically included in the Work of other Divisions.
3. Provide the materials and complete the required installations for equipment grounding as specified in Division 26 of these Specifications and indicated on the Contract Drawings.
4. Incidental items not specifically included in the Contract Documents that can legitimately and reasonably be inferred to belong in the instrumentation work shall be provided and installed by the Contractor at no additional cost to the Owner.
5. Field Wiring. For wiring materials, refer to Division 26 and Details on the Contract Drawings. Test signal wiring for continuity prior to termination. Provide wire number tags marked in indelible waterproof form of slip-on type heat shrink label or equal for each termination.

M. Process Connections.

1. Provide instrument piping, tubing, and capillary tubing to meet the intended process service and ambient environmental condition for corrosion resistance, etc. All instrument pneumatic tubing shall be Type 316 stainless steel. Slope lines according to service to promote self draining or venting back to the process. Terminate connection to process lines or vessels in a service rated block valve that will permit closing off the sense line or removal of the element without requiring shut down of the process. Include drip legs and blow-down valves for terminations of sense lines at the instruments when mounted such that condensation can accumulate. Process vessels, line penetrations, connecting fittings, and block valves shall be furnished and installed under other Divisions of these Specifications but coordinated by Division 40.

N. Electrical Transient Protection.

1. Instrument and control equipment mounted outside of protective structures (field mounted equipment) shall be equipped with surge-arresting devices to protect the equipment from damage due to electrical transients induced in the interconnecting lines from lightning discharges or nearby electrical devices. Both power and signal circuits shall be protected with surge and transient protectors installed at the source and destination ends of the circuits. Protective devices used on 120 VAC inputs to field mounted equipment shall be secondary surge protectors conforming to the requirements of IEEE C62.41 8/20 μ s wave form.
2. Surge and transient protectors shall be normally connected to the electrical system ground. When an electrical system ground is not available near the device, the protectors shall be connected to a ground rod located within 10 feet of the device. The ground rod shall meet all the requirements of Section 26 05 26 - Grounding and Bonding, in Division 26, Electrical.

3. Protectors for analog signal circuits on or near field instrument housings shall be Innovative Technology, Phoenix Contact Surge Trab Series, or accepted equal.
 4. Protectors shall be provided for conductors penetrating panel enclosures for power circuits protectors shall be Innovative Technology, Phoenix Contact PT Series, or accepted equal. For analog and data circuits protectors shall be rail mounted Innovative Technology, or accepted equal. Protectors for data utilizing coaxial connections shall be Innovative Technology, or accepted equal. Provide multi-stage gas tube and solid state Innovative Technology, or accepted equal, protectors for digital circuits.
- O. Spares and Maintenance Materials.
1. Furnish the following items as specified herein. Deliver to Engineer, as directed, with itemized list in a letter of transmittal accompanying each shipment.
 2. Materials shall be delivered in the manufacturer's original containers labeled to completely describe contents and equipment for which it is furnished.
 3. One Fuse of each size and type for every five used but no less than five of each type.
 4. One Relay of each type for every five used but no less than two of each type.
 5. One Panel Indicating Light Bulb for every five used but no less than four of each type.
 6. One Transient Protector for every five used but no less than four of each type.

PART 3 - EXECUTION

3.01 PRODUCT HANDLING

- A. Shipping Precautions: After completion of shop assembly, factory test, and acceptance, all equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- B. Special Instructions: Special instructions for proper field handling, storage, and installation required by the Manufacturer shall be securely attached to each piece of equipment before packaging and shipment.
- C. Tagging: Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the ICM system. Identification shall be prominently displayed on the outside of the package.
- D. Storage: Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be

repaired by the Contractor at no additional cost to the Owner. If any apparatus has been subject to possible damage by water, it shall be thoroughly dried out and put through tests as directed by the Engineer. Such tests shall be at no additional cost to the Owner, and if the equipment fails the tests, it shall be replaced at no additional cost to the Owner.

- E. Protection during Construction: Instrumentation and Controls shall at all times during construction be adequately protected against mechanical injury, water damage, corrosion, dirt, dust and foreign material. Equipment equipped with internal electrical heaters shall have them energized to keep the equipment dry. Doors to control panels and cabinets shall be kept closed at all times when work on them is not being done. Control Panels, Analyzers, sensitive electronic or computer equipment and/or controls or other materials not sealed and/or suitable for continuous outdoors storage shall not be stored out-of-doors. Such Instrumentation and Controls shall be stored in dry permanent shelters.
- F. Paint Finish: Any damage to factory applied paint finish shall be repaired using touch-up paint furnished by the instrument or equipment manufacturer.

3.02 MANUFACTURER'S SERVICES

- A. Furnish the following Manufacturer's services for all instrumentation provided:
 - 1. Perform bench calibration.
 - 2. Oversee installation.
 - 3. Verify installation of installed instrument.
 - 4. Certify installation and reconfirm Manufacturer's accuracy statement.
 - 5. Oversee loop testing, prepare loop validation sheets, and certify loop testing.
 - 6. Oversee pre-commissioning, prepare pre-commissioning validation sheets, and certify pre-commissioning.
 - 7. Train the Owner's personnel.

3.03 INSTALLATION

- A. General:
 - 1. All instrumentation, including instrumentation furnished under other Divisions, shall be installed per the manufacturers' instructions and Division 40.
 - 2. Equipment Locations: The monitoring and control system configurations indicated are diagrammatic. The locations of equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. All equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the Owner exercises the right to require changes in location of equipment that do not impact material quantities or cause material rework, make such changes without additional cost to the Owner.
- B. Conduit, Cables, and Field Wiring
 - 1. All conduit shall be provided, in accordance with Section 26 05 33.

2. All 4-20 mA signal circuits, process equipment control wiring, signal wiring to field instruments, remote I/O, PLC I/O, and other non-specialty field wiring and cables shall be provided and installed, in accordance with Section 26 05 05.
 3. All ICM system specialty cables, data highway fiber optic cable and specialty cable termination devices shall be provided under Division 40 and installed, in accordance with Section 26 05 05..
 4. All field cables and wiring terminations and wire identification at ICM system equipment furnished under this or any other Division shall be provided in accordance with the requirements of Section 26 05 05. All terminations shall be checked by the equipment supplier and the electrical contractor.
- C. Instrumentation Tie-Downs: All instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements that apply to the site.
- D. Existing Instrumentation: Each existing instrument to be removed and reinstalled shall be cleaned, reconditioned and recalibrated by an authorized service facility of the instrument Manufacturer. Provide certification of this Work before reinstallation of each instrument. Provide replacement for interim period as required.
- E. Ancillary Devices: The Contract Documents show all necessary conduit and instruments required to make a complete instrumentation system. The Contractor shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements at no additional cost to the Owner. All such additions and all such changes, including the proposed method of installation, shall be submitted to the Engineer for acceptance before commencing the Work. Such changes shall not be a basis of claims for extra work or delay.
- F. Installation Criteria and Validation: All field-mounted components and assemblies shall be installed and connected according to the requirements below:
1. Installation personnel have been instructed on installation requirements of the Contract Documents.
 2. Technical assistance is available to installation personnel at least by telephone.
 3. Installation personnel have at least one copy of the accepted and approved shop drawings and data.
 4. Instrument process sensing lines shall be installed similar to conduit. Individual tubes shall run parallel and near the surfaces from which they are supported. Supports shall be used at intervals of not more than 3-feet of rigid tubing.
 5. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square-cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at all panels requiring pipe or tubing entries.
 6. All differential pressure elements shall have three valve manifolds.
 7. All flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.
 8. All power and signal wires shall be terminated with crimped type lugs.
 9. All connectors shall be, as a minimum, water tight.

10. All wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.
11. All wire and cable shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically accepted by the Engineer. All wiring shall be protected from sharp edges and corners.
12. All mounting stands and bracket materials and workmanship shall comply with requirements of the Contract Documents.
13. Verify the correctness of each installation, including polarity of electric power and signal connections, and making sure all process connections are free of leaks. Certify in writing that for each loop or system checked out, all discrepancies have been corrected.
14. The Owner will not be responsible for any additional cost of rework attributable to actions of the Contractor or the CSI.

3.04 CALIBRATION

- A. General: All devices provided under the instrumentation Sections shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.
- B. Calibration Points: Each instrument shall be calibrated at 20, 40, 60, 80 and 100% of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Testing Standards.
- C. Bench Calibration: Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment. Such adjustments, if required, shall be made only after consultation with the Engineer.
- D. Field Calibration: Instruments that were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.
- E. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. All samples and sample gases shall be furnished by the manufacturers.
- F. Calibration Tags: A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the Engineer. Have the Instrumentation Supplier sign the tag when calibration is complete. The Engineer will sign the tag when the calibration and testing has been accepted.

3.05 LOOP TESTING

- A. General: Individual instrument loop diagrams per ISA Standard S5.4 - Instrument Loop Diagrams, expanded format, shall be submitted to the Engineer for review before the loop tests. The Contractor shall notify the Engineer of scheduled tests a minimum of 30 days before the estimated completion date of installation and wiring of the ICM. After the

Engineer's review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed. The loop check shall be witnessed by the Engineer.

- B. Control Valve Tests: All control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to ensure that no changes have occurred since the bench calibration.
- C. Interlocks: All hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers and packaged equipment controls shall be checked to the maximum extent possible.
- D. Instrument and Instrument Component Validation: Each instrument shall be field tested, inspected, and adjusted to its indicated performance requirement in accordance its Manufacturer's specifications and instructions. Any instrument that fails to meet any Contract requirement, or, in the absence of a Contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the direction of the Engineer at no additional cost to the Owner.
- E. Loop Validation: Controllers and electronic function modules shall be field tested and exercised to demonstrate correct operation. All control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA and PLC. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested. Specified accuracy tolerances for each analog network are defined as the root-mean-square-summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by Contract requirements or by published manufacturer accuracy specifications, whenever Contract accuracy requirements are not indicated. Each analog network shall be tested by applying simulated analog or discrete inputs to the first element of an analog network. For networks that incorporate analog elements, simulated sensor inputs corresponding to 20, 40, 60, 80 and 100% of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated root-mean-square-summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. All analog loop test data shall be recorded on test that include calculated root-mean-square-summation system accuracy tolerance requirements for each output.
- F. Loop Validation Sheets: Prepare loop confirmation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop confirmation sheets shall form the basis for operational tests and documentation. Each loop confirmation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop provided by the CSI:
 - 1. Project name.

2. Loop number.
3. Tag number, description, manufacturer and model number for each element.
4. Installation bulletin number.
5. Specification sheet number.
6. Loop description number
7. Adjustment check.
8. Space for comments.
9. Space for loop sign-off by Instrumentation Supplier and date.
10. Space for Engineer witness signature and date.

- G. Loop Certifications: When installation tests have been successfully completed for all individual instruments and all separate analog control networks, a certified copy of all test forms signed by the Engineer as a witness, with test data entered, shall be submitted to the Engineer together with a clear and unequivocal statement that all instrumentation has been successfully calibrated, inspected, and tested.

3.06 PRE-COMMISSIONING

- A. General: Pre-commissioning shall start after acceptance of all wire test, calibration tests and loop tests, and all inspections have demonstrated that the instrumentation and control system complies with all Contract requirements. Pre-commissioning shall demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
- B. Pre-commissioning Procedures and Documentation: All pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the Engineer as submitted by the CSI. All test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the Engineer, that include calculated tolerance limits for each step. Completion of all system pre-commissioning and test activities shall be documented by a certified report, including all test forms with test data entered, delivered to the Engineer with a clear and unequivocal statement that all system pre-commissioning and test requirements have been satisfied.
- C. Operational Validation: Where feasible, system pre-commissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under start-up and steady-state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. All hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady-state operation of final control elements running under the control of field mounted automatic analog controllers or software based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of field mounted, and software based automatic analog controllers shall be verified by applying control signal disturbances, monitoring

the amplitude and decay rate of control parameter oscillations (if any) and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

- D. Loop Tuning: All electronic control stations incorporating proportional, integral or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed set point settings shall be compared to measured final control element position/speed values at 20, 40, 60, 80 and 100% of span and the results checked against indicated accuracy tolerances.
- E. Pre-commissioning Validation Sheets: Pre-commissioning shall be documented on one of two types of test forms as follows:
 - 1. For functions that can be demonstrated on a loop-by-loop basis, the form shall include:
 - a. Project name.
 - b. Loop number.
 - c. Loop description.
 - d. Tag number, description, manufacturer and data sheet number for each component.
 - e. Space for sign-off and date by both the CSI and the Engineer.
 - 2. For functions that cannot be demonstrated on a loop-by-loop basis, the test form shall be a listing of the specific tests to be conducted. With each test description, the following information shall be included:
 - a. Specification page and paragraph of function demonstrated.
 - b. Description of function.
 - c. Space for sign-off and date by both the CSI and the Engineer.
- F. Pre-commissioning Certification: Submit an ICM system pre-commissioning completion report that shall state that all Contract requirements have been met and shall include a listing of all instrumentation and control system maintenance and repair activities conducted during the pre-commissioning testing. Acceptance of the instrumentation and control system pre-commissioning testing must be provided in writing by the Engineer before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.

3.07 ONSITE SUPERVISION

- A. Furnish the services of an on-site service engineer to supervise and coordinate installation, adjustment, testing, and start-up of the ICM system. The Engineer will be present during the total period required to affect a complete operating system. A qualified team of the Instrumentation Subcontractor personnel shall be on site as required to check all equipment, perform the tests indicated in this Section, and furnish startup services.

3.08 PERFORMANCE TEST

- A. The entire ICM system shall operate for 30 days without failure.
- B. Furnish all necessary support staff as required to maintain the system and to satisfy the repair or replacement requirements.
- C. If any component fails during the performance test, it shall be repaired or replaced within 4 hours and the ICM system shall be restarted. If the system is not repaired and running within four (4) hours or more than six component failures within the four (4) hour repair period, the system shall be restarted and operate for an additional 30 days without failure.

3.09 TRAINING

- A. Test entire ECM system.
- B. General: Train the Owner's personnel on the maintenance, calibration and repair of all instruments provided under this Contract.
- C. Instructions: The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.
- D. Duration: Each training class shall be a minimum of 8 hours in duration and shall cover, as a minimum, operational theory, maintenance, troubleshooting/repair, and calibration of instruments. Include a minimum of 4 hours training per instrument or control device; for PLC, and software include 8 hours for each type supplied.
- E. Schedule: Training shall be performed during the pre-commissioning phase of the project and 30 days after acceptance. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The Owner and Engineer will review the course outline and the training manual as submitted by the CSI for suitability and provide comments that shall be incorporated.
- F. Agenda: The training shall include operation and maintenance procedures, trouble shooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment.
- G. Documentation: Within 10 days after the completion of each session the Contractor shall submit the following:
 - 1. List of all Owner personnel who attended the session.
 - 2. Evaluation of Owner personnel via written testing or equivalent evaluation.
 - 3. Copy of the training materials used including all notes, diagrams, and comments.

3.10 ACCEPTANCE

- A. For the purpose of this Section, the following conditions shall be fulfilled before the Work is considered substantially complete:
 - 1. All submittals have been completed and accepted.
 - 2. The ICM system has been calibrated, loop tested and pre-commissioned.

3. The Owner training has been performed.
4. All required spare parts and expendable supplies and test equipment have been delivered to the Owner.
5. The performance test has been successfully completed.
6. All punch-list items have been corrected.
7. All record drawings in both hard copy and electronic format have been submitted.
8. Revisions to the operations and maintenance manuals information that may have resulted from the field tests have been made and reviewed.
9. All debris associated with installation of instrumentation has been removed.
10. All probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

3.11 WARRANTY

- A. Supplier shall warrant design, materials, and workmanship for customary period applicable for the equipment involved, but in no case for less than 24 months from date of acceptance, in accordance with the requirements of Paragraph 1.03, J, 1.
- B. During warranty period, if mechanical defects occur, or equipment fails to perform in accordance with specified performance requirements under conditions of normal use within the design limitations of the equipment, supplier shall, upon request of the company, repair or replace equipment or parts as required and shall place equipment in proper working condition, assuming all expenses involved.
- C. A written prepaid maintenance contract executed by the CSI shall be provided to the Owner for on-site warranty and travel maintenance services, in accordance with the requirements of Paragraph 1.03, H, and Paragraph I, 1. This maintenance contract shall include all travel and living expenses, labor, parts, and emergency calls providing on-site response within 4 hours, to provide complete system maintenance for a period of one year after the date of final acceptance of the system.
- D. The maintenance contract shall include a minimum of 4 (quarterly) preventive maintenance visits by a qualified serviceman of the Supplier who is familiar with the type of equipment and software provided for this project. Each preventive maintenance visit shall include routine adjustment, calibration, cleaning, and lubrication of system equipment and written verification of calibration and correct software operation.
- E. An annual fee shall be quoted 90 days before completion of the first year maintenance contract for annual maintenance subsequent to the first year of operation. Standard per diem rates for providing breakdown service shall be set forth in the contract. Such rates shall be fair and reasonable and reflect the lowest rates offered to most favored customers. The fee quoted shall be firm for a minimum of 90 days from day of issue.

END OF SECTION

SECTION 40 94 03
PROGRAMMABLE LOGIC CONTROLLER SUBSYSTEM (PLCS)

PART 1 - GENERAL

1.01 SCOPE

- A. General - This section describes the Programmable Logic Controller (PLC), Input/Output (I/O) equipment, Operator Interface Terminal (OIT), fiber optic industrial Gigabit Ethernet and associated network communication equipment, and associated hardware and equipment, PLC programming software, Human Machine Interface (HMI) SCADA application software including all engineering and programming and development required for monitoring and control. All devices, accessories, programming, and appurtenances required for proper operation of a complete and functional Instrumentation Control and Monitoring (ICM) system shall be provided.
1. The SCADA system shall be designed, coordinated, and supplied by a Control System Integrator (CSI) consisting of PLC based data acquisition and operator interface graphic display systems, who shall guarantee satisfactory operation of the installed ICM system.
 2. Develop and provide the PLC and SCADA HMI and OIT graphic display applications programs and hardware configuration needed to monitor and control the process equipment to perform the functional requirements as specified in Division 40 Sections or as required by the process equipment manufacturers and as required by and described in these Contract Documents.
 3. SCADA PLC's shall be configured and provided with hardware necessary to communicate with Ethernet enabled process instrumentation and equipment as required in these specifications.
 4. In general, communication network from structure to structure shall be via industrial redundant, self-healing Ethernet optical fiber network. Each PLC and Operator Workstation shall be provided with a UPS with a 30-minutes full load minimum. In the event of local power failure, the PLC shall automatically stop fault sequencing, PID windup, and continue accumulation of data and process calculations while notifying the operator via the HMI screens. Communication shall continue with PLC and workstations.

1.02 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.
1. National Electrical Manufacturers Association (NEMA).
 2. Instrument Society of America (ISA).

1.03 SUBMITTALS

- A. The Contractor shall make submittals in accordance with Divisions 01 and 40.
- B. The following information shall be provided:
1. Electronic copy of each of the following shall be submitted:
 - a. Manufacturers complete data.
 - b. Shop drawings, which include the following:

- i. Outline drawings of all components and a composite drawing.
 - ii. Schematic drawings of auxiliary piping and wiring.
- 2. Electronic copy of each of the following shall be submitted:
 - a. Operation and maintenance manual.
 - b. Training documentation.

1.04 TESTING

- A. Factory testing, field testing, and final acceptance testing of computers and programmable logic controllers shall conform to the requirements of Section 40 90 00.

1.05 WARRANTY

- A. Conform to warranty requirements of Division 40.
- B. The equipment manufacturers shall warrant and guarantee against defective equipment, workmanship, and materials under normal use, operation and service, for a period of 2 years after acceptance from the final date or resolution of the Owner accepting Work as substantially complete.

1.06 TOOLS, SUPPLIES AND SPARE PARTS

- A. Tools, supplies and spare parts shall be provided as required. In addition, the following specific spare parts items shall be provided:
 - 1. One of each type of CPU and co-processor module for PLC equipment furnished under this Contract.
 - 2. One of each type of input/output module for PLC equipment furnished under this Contract.
 - 3. One of each type and size of PLC and equipment power supply furnished under this Contract.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Provide Programmable Logic Controller including necessary equipment and appurtenances as manufactured by the following acceptable manufacturer:
 - 1. Allen Bradley – ControlLogix in the masin PLC panel
 - 2. Allen-Bradley – MicroLogix 1440 in Remote I/O panels.

2.02 PROGRAMMABLE LOGIC CONTROLLER AND I/O HARDWARE

- A. General
 - 1. Provide PLC hardware including processors, power supplies, rack assemblies, interconnecting cables, grounding system, communication modules, hot standby modules, and accessories required to perform the control and monitoring functions.
- B. Programmable Logic Controller (PLC)

1. The PLC shall be provided with the following minimum features:
 - a. The processor shall be the slot mount type, include at least 8MB available user memory. Minimum CPU shall be CompactLogix series.
 - b. The PLC system shall be able to accommodate the quantity and type of I/O points shown and described including future I/O points. In addition, provide 20% spare I/O points for each type, where a certain type of I/O is not required such as analog output, provide at least one such I/O module.
 - c. The PLC system shall include one Ethernet communication module. Ethernet communication module shall be used for permanent system-type communications from PLC to PLC and to HMI operator workstations throughout the plant. Data transfer rate shall be up to 1Gbit/s.
 - d. The PLC system shall operate over 0 to 60 degree Celsius temperature range, and a 0 to 95% (non-condensing) humidity range.
 - e. The processor shall include diagnostic indicators for power, mode, low battery, communications ports, and memory and I/O errors.
 - f. The PLC system shall allow on-line and off-line programming.
 - g. The CPU's shall have executive firmware which may be upgraded in the field using an upgrade/download procedure which does not require the removal and/or insertion of IC chip.
 - h. The PLC system shall be capable of communicating with third party devices such as Motor Control Centers, including Variable Frequency Drives (VFD), and packaged vendor equipment systems via Ethernet IP.
2. The PLC system in each control panel shall include a single or redundant processor (when shown on the drawings), power supply, and hot standby module. If the primary PLC system fails the standby PLC system shall assume primary control functions within 48 milliseconds of the failure. A failed component shall be able to be removed, replaced, and reloaded (with software) without shutting the on-line PLC system down. No special application programming shall be required to implement the hot standby PLC systems.
3. A power supply (quantity and size as required) shall be provided to supply power to the processor and I/O modules. The supply voltage to the power supply shall originate within the control panel and shall be 120 VAC. A separate 24 VDC power supply shall be provided to power the analog loops.
4. I/O modules shall be provided as required to accommodate the types and quantities of I/O points identified. Sample I/O point types include; dry contact outputs, 4-20 mA_{dc} analog inputs, 4-20 mA_{dc} analog outputs, and 120 VAC discrete inputs. Discrete inputs shall use 120 VAC as the voltage signal, and analog loop signals that leave the control panel shall use a 4-20 mA_{dc} current signal. I/O module point density shall not exceed 16 points per module. Each I/O module shall include front panel mounted diagnostic indicators for point status, fault conditions, and active conditions. The I/O modules shall be able to be replaced while under power and shall be keyed to prevent the wrong type of module from being inserted in the wrong slot. All I/O modules shall have removable terminal blocks for termination of field wiring. All terminal blocks shall be 'keyed' to prevent application of terminal block to wrong I/O module. All I/O modules shall report to the CPU should a terminal block fail or be removed.
5. The PLC and I/O modules rack assemblies shall be housed in the control panels as specified.

6. The control panels shall be provided with sufficient I/O modules to allow 20% spare installed and wired I/O points. Spares shall be provided for each different type of I/O.
7. The PLC and I/O equipment shall be a standard industrial grade product mechanically and electrically suitable for use in an industrial environment with a satisfactory product history of at least five years.

2.03 PROGRAMMABLE CONTROLLER APPLICATION & DEVELOPMENT SOFTWARE

- A. The PLC programming and configuration software shall be the manufacturer's latest version, and compatible with the Windows 11 operating system. The software package shall consist of all programming, configuration, and documentation software needed to place the control and information system in satisfactory operation. The software shall allow on-line and off-line program development and documentation. Programming shall be accomplished through the use of ladder logic and other IEC 1131.3 languages. PLC programming software shall include electronic documentation.
- B. Third-party programming software shall be acceptable if recommended by the manufacturer and if that software exceeds the capabilities of the PLC manufacturer's standard software package.
- C. All configuration and programming software necessary shall be provided on each operator workstation computer specified, including the Portable Laptop Programming Terminal, for connection to any PLC processor on the Ethernet network or via direct connection to the processor communications port. All necessary hardware drivers required to perform PLC configuration and programming shall be provided.
- D. If available, the configuration and programming software shall support communication over the network to implement its functions remotely from an operator workstation. All configuration and programming software necessary to implement this functionality shall be provided on the SCADA System Operator Workstations. All necessary hardware and software drivers required to allow the operator workstation to perform PLC configuration and programming shall be provided.
- E. The ladder logic instruction set for the PLC shall include the following, as a minimum:
 1. Relay type instructions.
 2. Counter and timer instructions.
 3. Comparison instructions (equal, greater than, limit tests, etc.).
 4. Integer and floating point mathematical instructions.
 5. Advanced math and trigonometric functions.
 6. Statistical instructions.
 7. Matrix and array instructions.
 8. Logical instructions (and, not, or, etc.).
 9. BCD conversion instructions.
 10. Bit modification, moving, and shift instructions.
 11. File instructions (search, copy, fill, etc.).
 12. Diagnostic instructions.
 13. Sequencer instructions.
 14. Program control instructions (jump, goto, subroutine, etc.).

15. PID control loops.
 16. Block read and write capability.
 17. Send/receive messages.
 18. Immediate I/O and communications update instructions.
- F. The PLC programming & configuration software shall be the latest version of RSLogix as required.

2.04 SCADA HMI APPLICATION SOFTWARE

- A. Provide an operator interface software package that, when combined with the operator station computer hardware, will gather, display, and store real-time operating information. The operator interface software package shall be sized according to the appropriate I/O point count and shall be able to accommodate 20% additional I/O in the future, but as a minimum shall accommodate 10,000 I/O.
- B. HMI Application Software
1. The operator interface software package shall provide the following minimum functions:
 - a. Compatible with Windows 11 Pro operating system.
 - b. The software package shall be provided with the appropriate Ethernet driver software, Ethernet hardware interfaces, and required Ethernet communication/configuration interface software as required.
 - c. The SCADA software shall utilize existing HMI software package.
 - d. Database management shall be performed using Microsoft SQL Server Database. The ability to store historical data (analog or digital) to daily, weekly, or monthly files and the ability to archive historical data to tape.
 - e. Report writing software shall be the latest version of XLReporter by SyTech, Inc., or accepted equal. The system integrator shall coordinate directly with the owner on types of required report as well as the reports format, etc.
 - f. Analog data shall be configured to be stored as average, minimum, maximum, or instantaneous values, in the proper engineering units.
 - g. A complete alarm handling package shall be provided that shall annunciate alarms in an alarm queue and allow them to be displayed on the process graphic displays with messages or by changing colors or otherwise massaging graphic display symbols. An alarm summary screen shall be provided. Alarms shall be able to be acknowledged by an operator at the operator station CRT on an individual or screen basis and nuisance alarms shall be able to be disabled. Alarms shall be logged to the alarm printer.
 - h. Password protection for the various levels of access (day-to-day functions versus configuration changes), Log in and Log out at all times and Auto log off with set time.
 - i. The data base points shall be identifiable by tag numbers.
 - j. The entire system configuration, including database, shall be able to be backed up on Cloud Storage (cloud services shall be prepaid by the system integrator for at least 3 years) as well as a local External Drive.
 2. Real Variables Processing.
 - a. Real Variables shall represent process data for which there are analog signal inputs to the system. The system shall sample each of these input signals at their selected scan

frequency, and perform the proper conversions and scaling to obtain the instantaneous engineering values. These values then shall be used to update real-time data on CRT displays, check for alarm conditions, and store for use in the historical files.

3. Calculated Variables Processing:
 - a. Calculated variables shall represent process parameters for which there are no direct analog inputs to the system. These variables shall utilize Real Variables, and manually entered constants or laboratory data to compute their value.
 - b. There shall be two types of calculated variables defined:
 - i. Calculated Variables that utilize one or more Real Variables and/or manually entered constants. These variables shall be treated in the same manner as Real Variables and shall have the same attributes as Real Variables (including alarming and control), with the exception that the calculation shall be performed automatically every 5 seconds.
 - ii. Calculated Variables which are used only for the Daily, Monthly, and Annual Operation Summary reports, and which utilize laboratory input data shall be computed once a day for inclusion in the Daily report and stored for use in the Monthly and Annual reports. The capability to display these variables shall be provided.
 - c. The System shall provide for a minimum of 4096 calculated variables.
4. Manual Input Data Handling.
 - a. The application software shall provide the capability to enter data manually from any operator's keyboard. This data shall consist of additional values for the current data file (e.g., laboratory analyses), inserting alarm limits, set point changes, adjustments to process constants, control system set point changes and system tuning parameter adjustments.
 - b. All manually entered data shall be entered and stored in the appropriate engineering units. All data entered shall be displayed for confirmation on the data entry device prior to incorporation to the data base.

2.05 MANAGED ETHERNET SWITCHES

- A. The managed Ethernet switch will be IEEE 802.3 compliant.
- B. The switch shall be powered by a nominal 24VDC supply.
- C. The switch will have a permissible voltage range of 18.5 VDC to 30.2 VDC
- D. Switch will support redundant power inputs that allow immediate switchover without switch operation interruption.
- E. The switch shall have an operating temperature range of 0°C to +55°C.
- F. The permissible storage temperature range for the switch will be -20°C to +70°C.
- G. The switch will withstand a maximum continuous operating humidity of 95% without condensation.
- H. Units should be of fan-less design to increase reliability

I. Switching Capabilities:

1. Auto-negotiation.
 - a. All Copper TX ports will support auto negotiation.
 - b. Each TX port will be able to interface to 10/100/1000 Mbps or full/half duplex devices.
 - c. Fiber optic ports will support continuous 10/100/1000 Mbps full duplex communications.
2. Auto Cross.
 - a. All TX ports will support MDIX providing cable autocross capability.
3. Auto Polarity.
 - a. The switch will support automatic port polarity change in the event a pair of twisted pair receive cables (RD+/RD-) are connected incorrectly.
4. Serial Interface.
 - a. The device will have a V.24 RS232 communications interface.
5. Accuracy & Capacity of switching table.
 - a. The switch will only forward valid Ethernet frames using the store and forward, or equivalent method.
 - b. The MAC address table will have a storage capacity of 8000 addresses.
6. Configurations.
 - a. The switch will support a removable memory device for the storing of switch settings, and the ability to share settings among like switches.

J. Diagnostics:

1. Port Status LED's.
 - a. Link: Each port will have an LED indication that there is a proper electrical connection to the attached device as well as providing indication that there is port activity.
 - b. Communication: Each port will have an LED indication for detection of packet collisions, and showing communication duplex mode.
 - c. To simplify the process of troubleshooting, the status indication of heavy communications traffic vs. the status of an active link with no communications traffic will be unambiguous.
2. LED Display.
 - a. The switch will employ a multi-position diagnostic display for reporting various startup and operational states, or error conditions that may occur.
3. Alarm Contact.
 - a. Switch to be equipped with an alarm contact to enable automatic audible or visual alarm in the event of loss of port communication, or either (or both) power supply inputs.
 - b. Switch to be equipped with an LED to indicate the status of the alarm contact.
4. Power Supply LED.
 - a. Switch will have a separate power indication LED for each power supply connection.

K. Internal Switch Functions:

1. Simple Network Management Protocol (SNMP).
 - a. The switch will support SNMP v1, v2 for network monitoring and configuration.

- b. The switch will operate with any industry MIB browser.
 - c. Switch will have a system of fully configurable SNMP Trap messages.
- 2. Device Addressing.
 - a. The switch will, by default, support dynamic device addressing via BootP.
 - b. The switch will be capable of operation with a static IP address assignment.
 - c. Support for switch IP address assignment via DHCP will be available.
 - d. Switch address can be set via serial port connection.
- 3. Redundancy.
 - a. Rapid Spanning Tree Protocol (RSTP).
 - i. The switch will conform to the IEEE standard 802.1w for redundancy.
 - ii. The switch will support redundant port connections and loops without causing network operation failure
 - iii. The system of redundancy will be applicable for any network topology
 - iv. Entire redundancy method will be integral to the individual switch and not dependent upon a separate management device.
 - b. Fast Ring Detection (FRD).
 - i. The Switch shall support the RSTP extension Fast Ring Detection to enable data channel recovery times faster than standard RSTP.
 - c. Media Redundancy Protocol (MRP).
 - i. Switch will support MRP in accordance with the IEC protocol 62439.
- 4. Web-Based Management.
 - a. The switch will be programmed with an embedded web server.
 - b. The web server will provide a comprehensive configuration, and diagnostic mechanism for the switch.
- 5. Security.
 - a. The switch will provide the user the ability to entirely disable the Web-based management interface.
 - b. Switch will support an IP address based method for restriction of Web server access.
 - c. Modifications to switch settings will be protected by a user selectable/changeable password.
 - d. The switch will support an optional MAC address based mechanism for controlling port access.
- 6. Port Mirroring.
 - a. The switch will have the capability to send a copy of all network packets seen on one switch port to a network monitoring connection on another switch port.
 - b. The switch will support mirroring of both ingress and egress traffic.
- 7. Firmware Administration.
 - a. The switch will be structured so that future functionalities can be added through firmware upgrades.
 - b. The switch will have the capability to receive firmware upgrades as a field serviceable process.

- c. Firmware upgrades will be performed via the integrated web server in conjunction with any TFTP server software, or via the serial connection.
- 8. IGMP Snooping and Query.
 - a. The switch will be capable of passively monitoring IGMP (multicast) messages and dynamically creating appropriate groups for proper message forwarding.
 - b. The query interval and snoop aging times will be user configurable to up to 60 minutes.
 - c. The switch will support up to 128 multicast groups.
- 9. Large Ring Networks.
 - a. The switch will support a configurable "Large Tree" extension to the Rapid Spanning Tree option, making a ring topology suitable for 28 switches along the relevant path from the Root.
 - b. This support option will provide the capability of constructing an RSTP ring topology of up to 57 switches, when all switches are configured with same function.
- 10. Traffic Prioritization.
 - a. The switch will support multiple priority queues for adjusting the internal packet processing sequence.
 - b. The switch will employ "Strict Priority" for transmitting data telegrams to ensure all high-priority data packets are transmitted.
 - c. Switch will have a user settable internal prioritization for individual ports, so that the processing of Ethernet data for a particular port can be optimized.
- 11. Power over Ethernet (PoE).
 - a. Switch shall provide support of Power over Ethernet in compliance with IEEE standard 802.3af.
- 12. Virtual LAN (VLAN).
 - a. The switch is able to maintain up to 32 concurrent VLANs.
 - b. The switch will support GARP VLAN Registration Protocol (GVRP) for dynamic VLAN implementation.
- 13. Link Layer Discovery Protocol (LLDP).
 - a. The switch will support LLDP according to IEEE 802.1ab, for topology detection of devices that also have LLDP activated.

- L. Managed Ethernet switches shall be Allen Bradley, N-Tron, Cisco, Phoenix Contact, Hirschman, or accepted equal.

2.06 UNMANAGED ETHERNET SWITCH SPECIFICATION

A. Ethernet Interfacing & Switching Capabilities

- 1. The Unmanaged Ethernet switch will be IEEE 802.3 compliant.
- 2. The switches must be capable of reading and processing high priority Ethernet packets before low priority during times of heavy network traffic in accordance with the priority levels of IEEE 802.1P/Q.
- 3. Auto-negotiation:
 - a. All Copper TX ports will support auto negotiation. Each TX port will be able to interface to 10/100 meg or full/half duplex devices.

4. Auto Cross:
 - a. All TX ports will provide cable autocross capability.
 5. Accuracy & Capacity of switching table.
 - a. The switch will only forward valid Ethernet frames using the store and forward or equivalent method.
 - b. The address table will have a minimum capacity of 4000 addresses.
- B. Diagnostics.
1. Port Status LED's.
 - a. Link Active: Each port will have a LED indication that there is a proper electrical connection to the attached device.
 - b. Communications Status: Each port will have an LED indication of communications activity.
 - c. To simplify the process of troubleshooting, the status indication of heavy communications traffic vs. the status of an active link with no communications traffic will be unambiguous.
- C. Installation Requirements.
1. Mounting.
 - a. The Switch will be din rail mountable out of the box and without the need to add/assemble adaptor or similar mounting plates.
 - b. All power connections will be wired using removable connectors.
 2. Port Security.
 - a. The switch will be configured to accept optional security frames. When installed, these frames will lock inserted cables or plugs into place, then requiring the use of a small mechanical key for cable or plug removal.
- D. Environmental Specifications & Agency Approvals.
1. Temperature & Humidity.
 - a. The Switch will have an operating temperature range of 0 to 60c or greater. For extended application life, the maximum temperature will be a minimum of 10 degrees C lower than the specified operating temperature of the internal switch chips.
 - b. The switch will withstand a maximum continuous operating humidity of 95% without condensation.
 2. Electrical Noise Immunity.
 - a. The switch will conform to the IEC61000-4-2 to 4-8 series of noise specifications as specified below:
 - i. IEC 61000-4-2 Electrostatic Discharge: Criterion B.
 - ii. IEC 61000-4-3 Radiated Noise Immunity: Criterion A.
 - iii. IEC 61000-4-4 Fast Transient (Burst) Withstand: Criterion B.
 - iv. IEC 61000-4-5 Surge Voltage: Criterion B.
 - v. IEC 61000-4-6 Conducted Noise Interference: Criterion A.
 - vi. IEC 61000-4-8 Electromagnetic Field withstand: Criterion A.
 3. Shock & Vibration.

- a. The operating shock rating will conform to IEC60068-2-27 and withstand a shock pulse of 25G or more for 11ms.
 - b. The operating vibration spec will conform to IEC60068-2-6 (Criterion 3) at 5G 150Hz, in all 3 axis.
- 4. Agency Certifications.
 - a. The switch will be certified for UL/Cul 508.
- E. Unmanaged Ethernet switches shall be Allen-Bradley, N-Tron, Hirschman, Phoenix Contact, Weidmuller, or accepted equal.

2.07 ETHERNET COMMUNICATION NETWORKS

A. General

- 1. Ethernet links shall be provided to connect all PLC's to Network Interface Panels (NIP), Motor Starters (MCC), and Control Panels as shown on the Contract Drawings. The Ethernet communication system shall use modular rack or back of panel mounted components for interfacing with required field connections. Provide necessary racks, interface modules, gateways, segment couplers, power supplies, Fiber-to-Ethernet converters, fiber patch panels and all other components as necessary for a complete and operable Ethernet communications system.

PART 3 - EXECUTION

3.01 PROGRAMMABLE LOGIC CONTROLLER APPLICATION SOFTWARE & DEVELOPMENT

- A. Provide programming to produce completely annotated application programs. Application programs shall be produced on equipment supplied by the Contractor as part of the Work. The application programming shall be developed as follows:
 - 1. The application programs shall be developed in a neat, professional, logical, and efficient manner such that the available PLC memory is not wasted. The application programming shall be completely documented with detailed rung comments and address comments that correspond to tag numbers provided on the Contract Drawings or in the description of operation. Application programming that manipulates analog signals shall utilize values that are scaled in the proper engineering units and are of the correct magnitude. Formulas utilized shall be described in detail.
 - 2. Use the system descriptions from Contract Drawings, process equipment manufacturer supplied information, and other application-oriented documents to develop the application programs.
 - 3. The application programming shall account for the fact that an HMI operator interface will be communicating with the PLC. The programming and addressing schemes shall allow efficient and logical block mapping of points between the various pieces of equipment.
 - 4. Provide programming package software and hardware tools at the conclusion of the Project, including USB Memory drives and reference manuals.
- B. The manufacturer's license agreements for software packages shall be made out to the Owner.

3.02 SCADA HMI APPLICATION SOFTWARE DEVELOPMENT

A. Data Management.

1. The workstations shall scan the PLC's on demand and as necessary to retrieve and send analog, discrete and virtual input information for displays, control and related operator workstation functions. The current database shall be resident in the distributed network devices as appropriate.
2. Elapsed running time values shall be maintained in the database for all process drives. This data shall be expressed in hours and tenths of hours and shall be updated every sixty seconds using the last scanned value for each associated discrete input. Accumulated runtime data shall be periodically updated (once per hour) in disk memory. The exact time and date of initiation shall be maintained for each runtime accumulation. The operator may, at any time, from any operator workstation, access historical or current accumulated runtime values and either display or print reports containing accumulated runtime for certain specified equipment (i.e., sorted by accumulated hours, equipment ID, etc. within a user specified range) or all equipment. The operator shall be able to selectively reset any or all runtime accumulations to zero (or other legal values). The specified spreadsheet and database software shall be furnished with all required macros/applications to perform the reporting functions.
3. For reporting purposes, the database shall perform averaging and integration on a point basis over the following time periods:
 - a. Five second – derived from readings accumulated at scan rates, stored for 3 days.
 - b. Five minutes – derived from above 5-second values, stored for 3 days.
 - c. Hourly – derived from above five-minute values, stored for 1 year.
 - d. Daily – derived from above one-hour values, stored for 1 year.
 - e. Monthly – derived from above shift values, stored for 1 year.
 - f. Annually – derived from above monthly values, stored for 1 year.

B. Graphic Display Organization - General

1. The display system described in the following paragraphs only defines those types of displays commonly used during normal operations and overall display organization. Displays shall be based upon information contained on the process flow diagrams, mechanical sheets, electrical drawings, other related drawings, and written narrative descriptions contained in the Specifications. The Contractor shall provide sufficient displays to satisfy all specified plant instrumentation and control system requirements
2. The description of the workstation operation in the remainder of this Section is based on the use of a mouse with screen icons. Should an alternate device be provided, operation shall be functionally equivalent to the procedures outlined below.
3. Alternative, but equivalent, graphic display formats and organization may be submitted for acceptance by the Engineer. However, any such substitutions shall conform to all functional requirements specified herein.
4. Each display format may consist of more than one page. If so, the display shall contain the message MORE (or other suitable descriptive text) as an icon on the bottom line and the next page shall be obtained by a strike on the "page forward" (PF) or the MORE icon. Backpaging shall be accomplished by a strike in the "page back" (PB) icon.

5. The Page Forward (FRWD) and Page Back (BACK) icons shall permit the user to page forward and backpage on a multipage listing. If a listing is larger than the capacity of a single CRT page, a MORE icon shall appear on the display. MORE means that there is more data for this display which can be accessed a page at a time with the MORE or FRWD icon. The BACK icon shall be used to reverse the forward display sequence, a page at a time. FRWD or BACK icons shall not be used on a single page display.
6. For map based and/or site plan displays, system pan/zoom features as well as system vertical horizontal and vertical scroll bars may be used for this purpose.
7. Vector targets shall be employed to move vertically and laterally between related displays or, alternatively, the vertical and horizontal window can be used, where appropriate.
8. The formats for all schematic diagrams (e.g., unit process, process partition and control strategy diagrams) shall be based on the site plan, mechanical and electrical power distribution drawings and shall be submitted to the Engineer for review. Process displays shall generally be site plan oriented, unless otherwise accepted by the Engineer.
9. The operator screens shall be made of any number of the following components, as appropriate:
 - a. Static and dynamic alphanumeric information.
 - b. Static and dynamic graphic objects.
 - c. Dynamic bar graph displays.
 - d. Dynamic analog trending displays.
 - e. Password protected operator actions.
 - f. Screen navigation commands.
10. Dynamic analog information shall be capable of at least eight value related color changes with or without flashing in response to a change in value, state, or alarm condition for linked tags. Dynamic displays linked to digital tags shall be capable of displaying at least three states with corresponding color/flash indications.
11. All data displayed in operator screens on each workstation shall be valid and current. Current values displayed in operator screens shall be instantly replaced with an error indication for "bad" data, loss of data or loss of communications for each individual tag. These conditions shall be treated as alarms, with specified reporting and routing.
12. When communications are restored and/or errors are cleared, data displays shall automatically display actual values, and "change in status" messages shall be routed to all alarm reports and files.
13. While viewing screens, and through password access, operator interaction with individual, modifiable data points shall include: value changes; placing points on/off scan; manual/automatic mode changes; alarm acknowledge; alarm enable/disable; etc.
14. A "pick" point in an operator screen indicates possible operator interaction for data entry, screen navigation or task switching. When the mouse pointer is "dragged" across operator "pick" points, a highlight box shall appear around each. In addition to pointing and clicking, the operator may press the "down" arrow key, to select a "pick" point and then press enter.
15. Point-click procedures shall be available for all operator/screen interface for navigation, data entry, etc. Operator data entry procedures shall be configured as keyboard entry; point-click calculator; multiple choice point-click, up/down ramping or data value slide.

16. Provide user changeable lower, upper and rate-of-change limits on all screen setpoint entry points. Initial limits shall be set at: lower = 10%, upper = 85% and rate-of-change = 10% of value. The user shall not be able to enter setpoint changes beyond these valid limits.
17. Configure the software at each workstation to check, verify and require appropriate password login prior to each start/stop action, setpoint change, tuning parameter change or any other equipment control or functional change.
18. The system shall respond to each operator request to perform any of these actions in the following manner:
 - a. Present a "pop up" start/stop faceplate screen with start and stop push buttons for each individually or grouped equipment start/stop system requirement.
 - b. Present a "pop up" setpoint entry faceplate screen for each system setpoint change requirement.
 - c. Present a "pop up" control parameter tuning faceplate screen for each system control parameter tuning requirement.
 - d. English language operator prompting prior to any system response to operator request. Prompting shall inform the operator of the action about to be taken and provide a confirming "proceed" or "quit" choice.
 - e. Each action and system response shall be clearly displayed in the appropriate "pop up" screen.
 - f. System response indication shall be the most positive feedback required by this specification. At a minimum, the actual PLC register containing the data to be verified shall be displayed and shall be used for any sequential, interlocked or other related control scheme.
 - g. At a minimum, each "pop up" screen shall provide for operator input/action and positive feedback indication. Each digital and feedback control display shall provide an English word rather than a digital number indicating conditions. These shall be: start, stop, enable, disable, etc.
 - h. Each variable input shall allow operator keyboard or vertical slide bar data entry. Each variable, input, and feedback shall be displayed in number and bar graph formats, both individually and in color-coded multiple bar chart for system evaluation.
19. Objects in screens shall indicate field status, such as "stopped" or "running" by appropriate animation, positioning and color coding.
20. The software at all workstations shall be configured to allow password protected user screen configuration without the use of dedicated programmers, the need to change or reconfigure hardware or cabling, or the need to reboot.

C. Graphic Screen Navigation

1. Each operator screen display shall be configured with a multiple choice Menubar at the top of the screen. Each selection button shall display a related pull down menu of additional selections, screen navigation, system administration, diagnostics and task switching with appropriate password protection.
2. Each selection shall be made by a single point-click or by pressing the "down" arrow to the appropriate selection and then pressing [ENTER]. None of these selections shall cause screen updating, database updating, data collection, alarm monitoring or any other system function to pause or stop.

3. When a Menubar selection is made, the Menubar button and text for that selection shall protrude and become bold to positively indicate user's selection, and the pull-down menu shall be displayed. When pull-down menus are closed or when a new operator screen is displayed, Menubar selections return to previous, normal states.
4. Menubar selections and related pushbutton menu selections and functions shall include:
 - a. SYSTEM Menubar selection: shall display a pull down menu with the following selections:
 - i. SECURITY LOGIN selection: shall display a password login dialogue box, enabling the system user to login by entering an assigned login name and password.
 - ii. SYSTEM ADMINISTRATION selection: shall provide a pull down menu with the following selections:
 - a) SECURITY CONFIGURATION selection: shall display workstation security configuration dialogue boxes enabling the user, through password protection, to modify or disable/enable workstation security functions.
 - b) FILE MANAGEMENT selection: shall provide the user with password protected access to Windows file manager.
 - c) TASK MANAGER selection: shall provide the user with password protected access to the Windows Task Manager through which any Windows program can be run.
 - d) HISTORICAL CHART CONFIGURATION selection: shall provide password protected access to workstation historical chart, pen and time group configuration through which the user shall be able to view, add and modify historical data charts.
 - e) SYSTEM BACKUP selection: shall provide password protected access to the workstation on-board CD-ROM or tape drive backup function, through which the user shall be able to partially or totally backup workstation software files.
 - iii. MESSAGE CENTER selection: shall provide access to a personal message center, through which users shall be able to provide brief messages to other users at any workstation on the network.
 - iv. DIAGNOSTICS selection: shall display a pull down menu providing the following selections:
 - a) NETWORK STATUS selection: shall provide workstation network diagnostics indicating status of all network sessions, activity and trouble.
 - b) I/O COMMUNICATION STATUS selection (available on the field I/O server workstations): shall provide password protected interactive display indicating data request/transmit communications status and error conditions between the field I/O server workstation and the PLC data highway.
 - c) COMPUTER DIAGNOSTICS selection: shall provide password protected total workstation review and diagnoses of computer hardware, memory, drives, ports, etc. This function shall also provide hard copy reporting of the entire diagnostics review or any portion thereof.
 - v. FIELD I/O AND PLC CONFIGURATION selection: shall provide a set of screens for each PLC including:
 - a) Manufacturer

- b) Model Number
- c) Rack I.D.
- d) Model number, type and location for each rack module.
- e) I/O device, associated database tag, and module position for all field I/O points.
- vi. SYSTEM ACTIVITY selection: shall provide a password protected pop-up display of live system activity including alarms, alarm resets, operator entries, communication errors, system messages and database configuration activity. This display shall be used to provide real time feedback for operator requests, troubleshooting, alarm management assistance, etc. This pop-up display shall be sized, moved, closed and set to be always "on-top" during screen navigation by user request and at any time without pausing or stopping data updates, data collection or alarm monitoring.
- b. ALARM Menubar selection; shall provide user interactive alarm summary screen as specified in the alarms section of this specification.
- c. HELP Menubar selection: shall provide project-specific full-function Microsoft Windows help including: "contents", "search", "back", etc.
- d. TREND Menubar selection: shall provide a pull down menu selection listing for:
 - i. LIVE TREND choice: shall provide a multiple trend menu of predefined live trends.
 - ii. HISTORICAL TREND selection: shall provide a menu selection listing of predefined historical trends.
- e. REPORTS Menubar selection: shall provide access to a menu listing for all configured reports with features as described herein.
- f. DISPLAY MENU Menubar selection: shall display a menu of all plant area displays for screen navigation.
- g. OVERVIEW Menubar selection: shall display the plant overview screen.
- h. PRINT Menubar selection: shall print the current display.
- i. CONTROL PANEL Menubar selection: shall provide date and time display and access to Microsoft Windows Control Panel. A single point-click action from a supervisor's security level or above shall display the Control Panel icon group through which modification can be made for:
 - i. System Date and Time.
 - ii. System Fonts.
 - iii. Printers Setup.
 - iv. Other Standard Windows Control Panel Functions.

D. Process Overview Display(s)

1. The process overview graphic display shall be obtained by selecting the OVERVIEW icon. One or more targets or icons shall be provided for each unit process and shall permit the operator to directly access an associated unit process display. The plant site plan layout shall be used as the basis for the process overview display, which shall provide display vectoring functions to subordinate unit process displays. A separate display containing a text-based listing of all system graphic displays shall also be provided, accessible from the Overview Display or a separate Menubar selection.

2. Intermediate process overviews shall be provided to summarize information from a number of similar or identical unit process equipment items (e.g., filter overview showing all filters, aeration system overview, etc.). These intermediate overview displays shall allow vectoring to/from the plant overview(s) and the individual equipment detail displays, and shall show appropriate summary process data.

E. Functional Area Display (s)

1. Functional Area Display(s) Unit Process Graphic Displays shall be provided to show all plant process areas and equipment in detail. Except where specified otherwise, all operator control actions shall be performed at the Unit Process Display level. Any unit process display shall be selectable from the process overview display or from an adjacent process area or otherwise related process display. A unit process display shall be a schematic representation of a process and use standard symbols to represent process equipment such as pumps, tanks, motors, etc. Process status shall be indicated using both color and alphanumeric annotations. Symbol color coding for all displays shall be based on the following convention:
 - a. Yellow blinking = device has a noncritical alarm not yet acknowledged.
 - b. Yellow = device has a noncritical alarm that has been acknowledged.
 - c. Magenta blinking = device has critical alarm not yet acknowledged.
 - d. Magenta = device has a critical alarm that has been acknowledged.
 - e. Cyan = device off or not available. This may represent future equipment or equipment that has been taken off line for maintenance purposes.
 - f. Red = device is on, running, energized, open.
 - g. Green = device is available, ready to run, de-energized, closed.
 - h. White with a black target background = device is in automatic (or semi-automatic) control mode.
 - i. White with a blue target background = device is in manual mode.
2. All text shall be shown in white except alarm condition statements that are illuminated in either yellow or magenta.
3. The displays shall show all ID number, current status values and setpoints associated with a given process display and shall be updated with current values every five seconds or less.
4. The control status of each controllable device shall be modifiable and shall be displayed in text adjacent to that device. Control status shall be AUTO, MANUAL, AVAILABLE, etc., and shall be updated continuously. When the operator wishes to take control of the device or modify setpoints, the procedure shall be as follows:
 - a. The operator shall click on the device symbol with the mouse.
 - b. A dialog box shall appear which provides the current state or setpoint and enables the operator to make the appropriate change.
 - c. For two-state devices, the dialog box shall allow the operator to start or stop, open or close, or otherwise change the state of the device.
 - d. For setpoints and modulating final control devices (analog outputs), the dialog box shall display the old value, and shall allow the operator to enter a new value using standard Windows editing techniques. It shall also be possible for the operator to ramp the current value up and down by clicking on ramp targets.

- e. Prior to the execution of the operator-commanded action, a confirmation message and target shall be displayed stating the old and new values and asking the operator to confirm the modification.
- f. Control strategies shall be changed from AUTO to MAN or OFF (or vice versa) in the same manner as two-state devices.

F. Alarm & Event configuration

1. The operator workstation software shall be configured to provide alarm handling, reporting and archiving. Alarm grouping, printing and display shall be coordinated with Engineer and Owner prior to configuration.
2. Alarm management shall be provided for each database field input and shall include:
 - a. Alarm reporting enable or disable.
 - b. Alarm suppression to avoid nuisance alarms such as start up spiking.
 - c. Re-alarms.
 - d. Alarm routing to specific workstations and printers as appropriate.
 - e. Alarm grouping for specific visual and audible group notification.
 - f. Analog alarm types to include at least: low low; low; high; high high; rate of change; deviation; deadband; bad input; and off scan.
 - g. Discrete alarm types to include at least: change from normal; return to normal; change of state; bad input; and off scan.
 - h. Alarm acknowledgement and condition clear format.
3. The operator workstation software shall provide date and time stamped alarm reporting to at least five destinations. These destinations shall be:
 - a. Operator screen alarm summaries.
 - b. Alarm printers.
 - c. System alarm and history file.
 - d. System alarm and history display.
 - e. Workstation network.
4. All points or modules that have the capability of being alarmed for amplitude or rate of change limit violations, and all discrete alarm inputs shall be linked to an associated discrete point for alarm suppression under specified conditions. For example, when there is no flow through a flow meter, the "not running" signal from the associated prime mover shall be used to suppress all alarms associated with the flow signal. Time delays shall be provided as necessary to eliminate transient alarm annunciation under start-up/shutdown conditions.
5. All alarms shall be OLE and Windows Sound System enabled. Sound files shall be individually assigned to each alarm point.
6. The system shall provide an alarm summary display as a pre-defined dynamic link within the graphics package. This alarm summary display shall show a list of the pending alarms in the system. As new alarms are detected, entries shall be made to the display list. As the alarm conditions clear, the entries shall be removed from the list.
7. The alarm summary display shall be user-configurable to the extent that the user can select the placement of tag name, current value, descriptor, time of alarm, and alarm status on the line as well as the color codes to be used to indicate the various alarm conditions.

8. Only alarms, including the loss of network, data highway and individual field I/O point communications, shall be reported to operator screen alarm summaries, which shall allow the operator to sort alarms in descending or ascending time order. The operator shall also be allowed to apply various priority level filters and to reconfigure alarm summary columns for detailed analyses, while viewing.
9. Alarms shall be acknowledged from the alarm summary display either individually (by clicking on an alarm acknowledgement field) or by a full page using a menu pull-down. The system shall support up to twenty (adjustable) alarm messages in the summary display.
10. Each graphic display shall be configured with the indication of the last three alarms at the bottom of the screen.
11. An unacknowledged alarm shall flash in configured foreground/background colors until it is acknowledged. When an alarm is acknowledged, it shall stop flashing but remain displayed until the alarm condition is cleared.
12. When an alarm condition has been both acknowledged and cleared, the alarm statement shall be removed from the alarm summary.
13. Alarm summaries shall use system colors and provide at least the following column information:
 - a. Date and time.
 - b. Workstation name.
 - c. Tag number.
 - d. Tag description.
 - e. Alarm condition.
 - f. Tag value.
14. Configure alarm summaries with a distinctive color format for:
 - a. Background color.
 - b. High value alarms.
 - c. Low value alarms.
 - d. Rate-of-change alarms.
 - e. Digital status alarms such as change of state, change from normal, etc.
 - f. Plant area/access alarms.
15. The following color codes shall be used in conjunction with alarm displays:
 - a. Cyan = normal.
 - b. Yellow, blinking = noncritical, not acknowledged alarm.
 - c. Yellow = noncritical, acknowledged alarm.
 - d. Magenta, blinking = critical, not acknowledged alarm.
 - e. Magenta = critical, acknowledged alarm.
16. The following alarm condition statements shall be provided as a minimum:
 - a. RTN NRML - Return to Normal.
 - b. HIHI LMT - Second High Limit.
 - c. HI LMT - High Limit.
 - d. LO LMT - Low Limit.
 - e. LOLO LMT - Second Low Limit.

- f. ROC LMT - Rate of Change Limit.
 - g. STAT CHGE - Status Change.
 - h. OFF SCAN - Off Scan.
 - i. OPEN FAIL - Open Failure.
 - j. CLOSE FAIL - Close Failure.
 - k. START FAIL - Start Failure.
 - l. STOP FAIL - Stop Failure.
 - m. FAULT – Fault.
 - n. HI DEV - High Deviation.
 - o. LO DEV - Low Deviation.
 - p. DISCREP – Discrepancy.
 - q. UNAVAIL – Unavailable.
17. Date and time stamped alarm reporting shall be sent to alarm printers with similar formatting, configuration and routing procedures as specified for alarm summaries.
 18. Configure alarm and history files for sequential date and time stamped activity reporting for the entire system, on each workstation. This file shall be a daily text file with a file name indicating the date that the file was created, and shall include all system wide activity including:
 - a. Alarms.
 - b. Alarm acknowledgement.
 - c. Loss and recovery of network, data highway and individual field I/O point communications.
 - d. Status changes.
 - e. Alarm clear and return to normal messages.
 - f. Operator keyboard entries.
 - g. Other system related activity (system startup, save/reload database, etc.).
 19. Information format shall include:
 - a. Date and time.
 - b. Description.
 - c. Condition.
 - d. Current value.
 20. Alarm and history files shall be saved to computer backup media including CD's or tapes if selected by the operator.
 21. The alarm and history display shall provide live viewing of alarm and history file entries, giving the operator instantaneous activity review and operator action verification.
 22. The system alarm and history display, with on-line height and width adjustment capabilities, shall be displayed as part of operator screens, upon demand. The operator shall be able to size and move the display, as desired. Further, the operator shall be able to close this display, upon demand, or cause it to be continually displayed as the operator navigates through operator screens.
 23. The opening, closing, moving or resizing of this display shall not cause screen updating, database updating, historical data collection, alarm monitoring or any other system function to pause or stop.

24. Workstations shall be configured to report all alarm conditions, operator activity, etc. to all other workstations.
25. The system shall be configured to provide a periodic date stamp on the alarm printout at the alarm printer to provide clear date/time evaluation of printed alarms.
26. Each workstation shall be configured for alarm and history activity file backup and archiving to the on-board tape or CD drive. Provide alarm and history file backup, and disk space management procedures.

G. System Security

1. Observer.
 - a. Graphic display viewing and navigation.
 - b. Historical data display.
 - c. Password login and logout.
 - d. Observer shall be the system default security mode.
2. Operator.
 - a. Observer privileges.
 - b. Password protected start/stop, setpoint entries, system activity display, etc.
 - c. Lead Operator/Supervisor.
 - d. Operator privileges.
 - e. Historical data chart configuration.
 - f. Report viewing, modification and exporting/printing.
 - g. Task switching to the Windows operating system.
 - h. Software system shut down.
 - i. Windows NT Task Manager access.
3. System Administrator/Engineer.
 - a. All privileges.
4. The software at each workstation shall be configured to automatically log in the observer group upon system startup.
5. The security system at each workstation shall be configured to not allow SCADA software shut down or Windows NT security access unless requested through Supervisors' or System Administrator security privileges.
6. The security configuration shall be exportable to a text file, which shall not include passwords. This text file shall have a user defined acronymic, mnemonic file name and shall be capable of being imported into the system to modify or create workstation security configuration.
7. All workstation security activity, including violations, shall be reported in a date and time stamped format to a daily text file for review and evaluation at any time. This security text file shall have a file name indicating the date that the security file was created. It shall be possible for any text editor to edit these files.
8. Each workstation shall be configured for security activity file backup and archiving to the on-board tape drive.

H. Trend Configuration

1. The system shall provide multiple sets of live trends in operator screens. Each set of live trends shall be capable of the following:
 - a. Displaying up to eight pens.
 - b. Being temporarily modified, while viewing.
 - c. Displaying straight line or varying data value "target" curves.
 - d. Full screen trend curve displays when trend screen is opened.
 2. Each live trend chart shall allow temporary, on-line pen, range and chart X-Y parameter changes by the user. Each trend display shall allow on-line user modifiable straight-line "target" curve for each trended data point and, as specified, a user selected varying data value "target" curve based on pre-defined modeling for trended data points.
 3. Trends shall automatically shut down and release system resources when closed.
- I. Historical Data Management Configuration
1. The operator workstation SCADA, database, spreadsheet and reporting software shall be configured to provide historical data gathering for system and operations validating, testing, maintenance and regulatory reporting.
 2. The system shall provide multiple choice options for historical data file size and shall automatically assign file names indicating the date and duration for data contained in each file. The installed system shall be configured for sequential data files beginning at midnight.
 3. For data and system resource management the system shall allow the assignment of any number and type of database tags and tag groups for historical data collection with the following attributes:
 - a. Collection rate and phasing.
 - b. Data collection start/stop condition.
 - c. Data collection deadband.
 4. For additional resource management, the operator workstation software shall be configured to automatically delete historical data files when they reach a certain age, which is user selectable from a multiple choice options list. Set initial automatic file deletion at 20 days with backup and archiving procedures occurring prior to deletion.
 5. Configure each workstation for historical data files backup and archiving to Cloud Storage and local external Drive.
 6. Provide historical data files backup, and disk space management procedures.
 7. All attributes of each historical display chart shall be able to be configured or modified at any time.
 8. In addition, the user shall be able to make temporary, view only modifications, while viewing historical trend charts.
 9. The system shall be configured for the following on-line historical data user functionality, without pausing or stopping any system function:
 - a. Zoom to any specific area of a chart.
 - b. Automatic real time update of historical data, upon demand.
 - c. Reset to original trend chart parameters, upon demand.
 - d. Request completely different start/stop time and duration parameters, upon demand.
 - e. Chart data display update forward or backward in time, by a single point-click for two sets of modifiable time increments in each direction.

- f. Export displayed trend chart data into a text file with a user defined acronymic, mnemonic file name.
 - g. Print any displayed historical trend chart, upon demand.
 - h. Display multiple historical trend charts at the same time with time synchronizing for detailed analyses.
 - i. Data trend charts configured by combining any pen and time groups.
 - j. Trend chart display format changes including colors, titles, legends, etc.
10. When configuring tag pen groups, the system shall provide for user configuration of at least:
 - a. Individual tag and related attributes.
 - b. Default or specific data value range.
 - c. Individual color for each tag pen.
 - d. A specific letter to further document each pen related curve.
 - e. Trend chart display format.
 11. Time group configuration shall include at least the following:
 - a. Start/stop dates and times.
 - b. Duration.
 - c. Sample, average value, high value and low value displays individually or together.
 - d. Trend chart display format.
 12. Historical data files shall be saved to computer backup media including diskettes, tapes or optical disks if the operator chooses this option. The system shall allow these files to be restored to the appropriate system file path and reviewed with all system functions at any time, as if they had continued to be hard disk resident.
 13. The collection of historical data shall begin automatically upon software system start-up.
 14. All analog and digital field inputs shall be historically collected. Provide collected data in the "sample" mode with collection rate, phasing, etc. attributes assigned to maximize data collection and system resources.
 15. Provide the following time groups:
 - a. The previous hour.
 - b. The previous twenty-four (24) hours.
 - c. The previous thirty (30) days.
 16. Operator access for viewing or printing any individual project specific, pre-defined historical trend chart shall be through a single point-click action while viewing operator screens via the TREND Menubar selection.

J. Reports Configuration

1. The report generator shall employ the specified electronic spreadsheet, report writing and database programs to provide the user with an interactive method to define, change, and replace report formats. The specified database, spreadsheet, and reporting software shall be furnished with all required applications and macros to perform the specified reporting functions.
2. The report generator shall permit arithmetic, relational, logical and statistical operations on individual or groups of data values contained in the distributed database and shall be employed to build shift, daily, equipment runtime and other specified reports utilizing network based dynamic data exchange access to the databases.

3. The reporting module shall provide the user with all standard Excel-type interactive spreadsheet formats, functions, linking, various kinds of charts, live spreadsheet/database interaction, fonts, math functions, macros, print options, and report saving.
4. All tags in the Control and Information System, including inputs, outputs, calculations and historical data shall be available for use in reports. Points shall be referenced in report formats by tag names or pen/time groups, and linking to reports shall be automatic and transparent to the user.
5. Each report shall be capable of linking and displaying the following:
 - a. All attributes of database tags including:
 - i. Current value.
 - ii. Engineering units.
 - iii. Descriptors.
 - iv. Field I/O equipment addresses.
 - v. Alarm parameters.
 - b. Any combination of historian pen/time groups.
 - c. Manually entered data.
 - d. Text.
 - e. Date and Time.
6. The report package shall allow on-line user selection of a value or groups of values, and instantaneously create charts in X-Y, bar graph, pie and other formats. Charts shall be modifiable upon viewer demand. Chart printouts, on demand, shall be provided.
7. Reports shall display entries indicating "no data" and "bad data" to distinguish error conditions from zero values for individual report data links.
8. Report generation or configuration shall not cause screen updates, database updates, historical collection, alarm monitoring nor any other system operation to pause or stop.
9. The report module shall open on top of operator screens, so that, upon exiting, the previous operator screen shall be automatically displayed, and shall be fully functioning and updating.
10. The reporting of system operating data shall occur once per day at user-specified times. Data recorded on these reports shall be extracted from the operator workstation data files as required. Report data shall consist of the arithmetic average and sums of variable readings taken by the control system on scans made during the previous 24-hour period and from manually entered data. Where applicable, total, average, maximum, and minimum values shall be provided for each column of data on each report.
11. User access to any individual report shall be provided by means of a single point-click from a menu of all project specific reports.
12. Password protected access to reports shall also enable the user to create and/or modify reports through standard Microsoft Excel configuration and system macro procedures.
13. No reports access, work, viewing or any other reports related activity shall require the suspension, modification or the stopping/starting of the reports scheduler. Nor shall this activity cause any pausing or stopping of data updating, data collection, alarm monitoring, or any other Control and Information System function.

3.03 SYSTEM CONFIGURATION AND EXPANSION

- A. The system shall provide an on-line installation and configuration program for configuring the various computers on the network. This configuration software shall allow assigning unique node names to each computer as well as selecting the functions that the machine will perform.
- B. The system shall allow additional computers to be added to the network while on-line, without disrupting the operations of the other machines.

3.04 DIAGNOSTICS

- A. The system shall provide on-line diagnostics that display the current status and operation of the local area network and its nodes. The diagnostic display shall include the LAN adapter status for the machine showing the display, as well as the current number of messages, errors and retries.
- B. An additional display shall show the current session status (established, pending, offline) of all stations on the network. A session monitor program that automatically monitors and recovers communications shall be supplied with the system.

3.05 LICENSE AGREEMENTS/SECURITY

- A. The manufacturer's license agreements for software packages shall be made out to the Owner.
- B. Contractor developed application programs shall become the property of the Owner at the conclusion of the Contract. There shall be no license agreements of any kind for these programs.
- C. The Owner shall be provided with passwords required to access the PLC application programs and operator interface configuration data. There shall be no Contractor programmed security schemes that prevent access to the application programs or configuration data.

END OF SECTION

SECTION 43 23 10

WAS-RAS PUMPS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Work under this section includes, but is not limited to, furnishing and installing a factory built base mounted WAS/RAS pump station as indicated on the project drawings, herein specified, as necessary for proper and complete performance.

1.02 REFERENCES

- A. Publications listed below form part of this specification to extent referenced in the text by basic designation only. Consult latest edition of publication unless otherwise noted.
 - 1. American National Std. Institute (ANSI) / American Water Works Assoc. (AWWA)
 - a. ANSI B16.1 Cast iron pipe flanges and flanged fittings.
 - b. ANSI/AWWA C115/A21.51 Cast/ductile iron pipe with threaded flanges.
 - c. ANSI 253.1 Safety Color Code for Marking Physical Hazards.
 - d. ANSI B40.1 Gages, Pressure and Vacuum.
 - e. AWWA C508 Single Swing Check Valves.
 - 2. American Society for Testing and Materials (ASTM)
 - a. ASTM A48 Gray Iron Castings.
 - b. ASTM A126 Valves, Flanges, and Pipe Fittings.
 - c. ASTM A307 Carbon Steel Bolts and Studs.
 - d. ASTM A36 Structural Steel.
 - 3. Institute of Electrical and Electronics Engineers (IEEE)
 - a. ANSI/IEEE Std 100 Standard Dictionary of Electrical Terms.
 - b. ANSI/IEEE Std 112 Test Procedure for Polyphase Induction Motors.
 - c. IEEE Std 242 Protection of Industrial and Control Power Systems.
 - 4. National Electric Code (NEC) / National Electrical Manufacturers Assoc. (NEMA)
 - a. NEC National Electric Code.
 - b. NEC 701 National Electric Code article 701.
 - c. NEMA Std MG1 Motors and Generators.
 - 5. Miscellaneous References
 - a. Hydraulic Institute Std for Centrifugal, Rotary and Reciprocating Pumps.
 - b. NMTBA and JIC Std National Machine Tool Builders Association and Joint Industrial Council Standards
 - c. ISO 9001 International Organization for Standardization.

1.03 SYSTEM DESCRIPTION

- A. Contractor shall furnish and install three (3) factory built, individual base mounted, 10 HP Gorman-Rupp Model T6SA3-B pumps. The pumps shall be complete with all equipment specified herein; factory assembled on a steel base.
- B. Principal items of equipment shall include three (3) horizontal, self-priming, centrifugal pump, check valve, air release ball valve, V-belt drive, motor. Pumps shall be mounted on individual bases.

- C. Factory built pump and skid design, including materials of construction, pump features, valves and piping, shall be in accordance with requirements listed under PART 2 - PRODUCTS of this section.

1.04 PERFORMANCE CRITERIA

- A. Pumps must be designed to handle screened raw water sewage. Pumps shall have 6 inch diameter suction connection, and 6 inch discharge connection. Each pump shall be selected to perform under following operating conditions and shall match the performance of the existing pumps. Pumps will operate with a VFD supplied by others.
 - 1. RAS Flow – 460 gallons per minute at 30.7 feet of Total Dynamic Head
 - 2. WAS Flow – 150 gallons per minute at 30.5 feet of Total Dynamic Head
- B. Site power furnished to pump station shall be 3 phase, 60 hertz, 460 volts, 4 wire, maintained within industry standards. Voltage tolerance shall be plus or minus 10 percent. Control voltage shall not exceed 132 volts.

1.05 SUBMITTALS

- A. Product Data
 - 1. Prior to fabrication, pump station Manufacturer shall submit 6 copies of submittal data for review and approval.
 - 2. Submittal shall include shop drawings, and support data as follows: Catalog cuts sheets reflecting characteristics for major items of equipment, materials of construction, major dimensions, motor and v-belt drive data, pump characteristic curves showing the design duty point capacity (GPM), head (FT), net positive suction head required (NPSHr), and hydraulic brake horsepower (BHP).
- B. Shop drawings shall provide layout of mechanical equipment and anchor bolt locations for station. Contractor piping connections and station access clearances shall be dimensioned relative to the station centerline.
- C. Operations Maintenance Manuals
 - 1. Installation shall be in accordance with written instructions provided by the pump station Manufacturer. Comprehensive instructions supplied at time of shipment shall enable personnel to properly operate and maintain all equipment supplied. Content and instructions shall assume operating personnel are familiar with pumps, motors, piping and valves, but lack experience on exact equipment supplied.
 - 2. Documentation shall be specific to the pump station supplied and collated in functional sections. Each section shall combine to form a complete system manual covering all aspects of equipment supplied by the station Manufacturer. Support data for any equipment supplied by others, even if mounted or included in overall station design, shall be provided by those supplying the equipment. Instructions shall include the following as a minimum:
 - a. Functional description of each major component, complete with operating instructions.
 - b. Instructions for operating pumps in all modes of operation.
 - c. Calibration and adjustment of equipment for initial start-up, as required for routine maintenance.
 - d. Support data for commercially available components not produced by the station Manufacturer, but supplied in accordance with the specifications, shall be supported by literature from the prime Manufacturer and incorporated as appendices.
 - e. Mechanical layout drawing of the pump and components, prepared in accordance with good commercial practice, shall provide installation dimensions and location of all pumps, motors, and bases.

- f. Operation and maintenance instructions which rely on vendor cut-sheets and literature which include general configurations, or require operating personnel to selectively read portions of the manual shall not be acceptable. Operation and maintenance instructions must be specific to equipment supplied in accordance with these specifications.

1.06 QUALITY ASSURANCE

- A. The pumps and pump skid Manufacturer must be certified to ISO 9001 by an accredited certification agency.
- B. Upon request from the engineer, the pump station Manufacturer shall prove financial stability and ability to produce the station within the specified delivery schedules. Evidence of facilities, equipment and expertise shall demonstrate the Manufacturer's commitment to long term customer service and product support.
- C. All internal passages, impeller vanes, and recirculation ports shall pass a 3-inch spherical solid. Smaller internal passages that create a maintenance nuisance or interfere with priming and pump performance shall not be permitted. Upon request from the engineer, Manufacturer's certified drawings showing size and location of the recirculation port(s) shall be submitted for approval.
- D. Reprime Performance
 - 1. Consideration shall be given to the raw water service anticipated, in which debris is expected to lodge between the suction check valve and its seat, resulting in the loss of the pump suction leg, and siphoning of liquid from the pump casing to the approximate center line of the impeller. Such occurrence shall be considered normal, and the pump must be capable of automatic, unattended operation with an air release line installed.
 - 2. During unattended operation, the pump shall retain adequate liquid in the casing to insure automatic repriming while operating at its rated speed in a completely open system. The need for a suction check valve or external priming device shall not be required.
 - 3. Pump must reprime 5 vertical feet at the specified speed and impeller diameter. Reprime lift is defined as the static height of the pump suction above the liquid, while operating with only one-half of the liquid remaining in the pump casing. The pump must reprime and deliver full capacity within five minutes after the pump is energized in the reprime condition. Reprime performance must be confirmed with the following test set-up:
 - a. One (1) check valve to be installed downstream from the pump discharge flange. The check valve size shall be equal (or greater than) the pump discharge diameter.
 - b. A length of air release pipe shall be installed between pump and the discharge check valve. This line shall allow the air displacement rate anticipated at a typical pump station fitted with a ball valve style air release valve.
 - c. The pump shall have a suction check valve shall be removed. No restrictions in the pump or suction piping will prevent the siphon drop of the suction leg. Suction pipe configuration for reprime test shall incorporate a 2-foot minimum horizontal run, a 90 degree elbow and vertical run at the specified lift. Pipe size shall be equal to the pump suction diameter.
 - d. Impeller clearances shall be set as recommended in the pump service manual.
 - e. Repeatability of performance shall be demonstrated by testing five (5) consecutive reprime cycles. Full pump capacity (flow) shall be achieved within five (5) minutes during each cycle.
 - f. Liquid to be used for reprime test shall be water.

4. Upon request from the engineer, certified reprime performance test results, prepared by the Manufacturer, and certified by a registered professional engineer, shall be submitted for approval prior to shipment.
- E. Factory System Test
 1. All components including the pumps, motors, and controls will be tested as a complete working system at the Manufacturer's facility. Tests shall be conducted in accordance with Hydraulic Institute Standards at the specified head, capacity, rated speed and horsepower. Factory operational test shall duplicate actual performance anticipated for the complete station.
 2. Upon request from the engineer, the operational test may be witnessed by the engineer, and/or representatives of his choice, at the Manufacturer's facility.
- F. The Manufacturer's technical representative shall inspect the completed installation, correct or supervise the correction of any defect or malfunction, and instruct operating personnel in the proper operation and maintenance of the equipment.

1.07 MANUFACTURER'S WARRANTY

- A. The pump station Manufacturer shall warrant all equipment to be of quality construction, free of defects in material and workmanship. A written warranty shall include specific details described below.
 1. All equipment, apparatus, and parts furnished shall be warranted for one (1) year, excepting only those items that are normally consumed in service, such as light bulbs, oils, grease, packing, gaskets, O-rings, etc. The pump station Manufacturer shall be solely responsible for warranty of the station and all components.
 2. Components failing to perform as specified by the engineer, or as represented by the Manufacturer, or as proven defective in service during the warranty period, shall be replaced, repaired, or satisfactorily modified by the Manufacturer without cost of parts or labor to the owner.
- B. It is not intended that the station Manufacturer assume liability for consequential damages or contingent liabilities arising from failure of any vendor supplied product or part which fails to properly operate, however caused. Consequential damages resulting from defects in design, or delays in delivery are also beyond the Manufacturer's scope of liability.
- C. The warranty shall become effective upon the acceptance by the purchaser or the purchaser's authorized agent or sixty (60) days after installation, whichever occurs first.

PART 2 PART 2 – PRODUCTS

2.01 UNITARY RESPONSIBILITY

- A. In order to unify responsibility for proper operation of the complete pumping station, it is the intent of these Specifications that all system components be furnished by a single supplier (unitary source). The pumping station must be of standard catalog design, totally warranted by the Manufacturer. Under no circumstances will a system consisting of parts compiled and assembled by a Manufacturer's representative or distributor be accepted.

2.02 MANUFACTURER

- A. The pump station system must be certified to ISO 9001 by an accredited certification agency.

2.03 UNIT BASE

- A. The unit base shall comprise a base plate, perimeter flange, and reinforcements. Base plate shall be fabricated of steel not less than 1/4-inch thick, and shall incorporate openings for

access to all internal cavities to permit complete grouting of unit base after installation. Perimeter flange and reinforcements shall be designed to prevent flexing or warping under operating conditions. Base plate and/or flange shall be drilled for hardware used to secure unit base to concrete pad as shown on the contract drawings. Unit base shall contain provisions for lifting the complete pump unit during shipping and installation.

2.04 PUMP DESIGN

- A. The Manufacturer of the pumps must be ISO 9001:2008 revision certified, with scope of registration including design control and service after sales activities.
- B. Pump shall be horizontal, self-priming centrifugal type, designed specifically for handling raw unscreened domestic sanitary sewage or industrial waste. Pump solids handling capability and performance criteria shall be in accordance with requirements listed under PART 1 - GENERAL of this section.
- C. The cover plates and rotating assemblies shall be interchangeable between both casings.
- D. Materials and Construction Features
 - 1. Pump casings shall be cast iron Class 30 with integral volute scroll. Casing shall incorporate following features:
 - a. Mounting feet sized to prevent tipping or binding when pump is completely disassembled for maintenance.
 - b. Fill port cover plate, 3-1/2 inch diameter, shall be opened after loosening a positive lock clamp bar assembly. In consideration for safety, capscrew threads must provide slow release of pressure, and the clamp bar shall be retained by detente lugs. A non-metallic gasket shall prevent adhesion of the fill port cover to the casing while assuring a reliable seal.
 - c. Lower casing drain plug shall be at least 1-1/4 inch NPT to insure complete and rapid draining.
 - d. Liquid volume and recirculation port design shall be consistent with performance criteria listed under PART 1 - GENERAL of this section.
 - 2. Cover plates shall be cast iron Class 30. Design must incorporate the following maintenance features:
 - a. Retained by hand nuts for complete access to pump interior. Cover plate removal must provide ample clearance for removal of stoppages, and allow service to the impeller, seal, wear plate or check valve without removing suction or discharge piping.
 - b. Self-Cleaning Wearplate
 - i. Replaceable wear plates secured to the cover plates by weld studs and nuts shall be AISI 1015 HRS. Wear plates shall be self-cleaning design ensuring that debris is cleared away and does not collect on the impeller vanes.
 - ii. The nature of the conveyed medium poses significant challenges to the continuous operation of the pump. Of particular concern is the clogging of the impeller by debris in the pumped medium including but not limited to long rags, fibers, and like debris which are able to wrap around the impeller vanes, stick to the center of the vanes or hub, or lodge within the spaces between the impeller and the housing.
 - iii. The wearplate shall have one or more notches and/or recesses provided along a common diameter of the wearplate to disturb and dislodge any solids which might otherwise remain on the impeller in dynamic operation. Clusters of notches and/or recesses may also be provided.
 - c. In consideration for safety, a pressure relief valve shall be supplied in each pump.
 - d. O-rings of Buna-N material shall seal each cover plate to pump casings.

- e. Pusher bolt capability to assist in removal of cover plates. Pusher bolt threaded holes shall be sized to accept same retaining capscrews as used in rotating assemblies.
- 3. Each rotating assembly, which includes impeller, shaft, mechanical shaft seal, lip seals, bearings, seal plate and bearing housing, must be removable as a single unit without disturbing the pump casing or piping. Design shall incorporate the following features:
 - a. Seal plates and bearing housings shall be cast iron Class 30. Anti-rotation ribs shall be cast into the seal plates to reduce internal wear and maximize component life. Separate oil filled cavities, vented to atmosphere, shall be provided for shaft seal and bearings. Cavities must be cooled by the liquid pumped. Three lip seals will prevent leakage of oil.
 - i. Each bearing cavity shall have an oil level sight gauge and fill plug check valve. The clear sight gauge shall provide easy monitoring of the bearing cavity oil level and condition of oil without removal of the fill plug check valve. The check valve shall vent the cavity but prevent introduction of moist air to the bearings.
 - ii. Each seal cavity shall have an oil level sight gauge and fill/vent plug. The clear sight gauge shall provide easy monitoring of the seal cavity oil level and condition of oil without removal of the fill/vent plug.
 - iii. Double lip seals shall provide an atmospheric path providing positive protection of bearings, with capability for external drainage monitoring.
 - b. Impellers shall be ductile iron, two vane, semi-open, non-clog, with integral pump out vanes on the back shroud. Impellers shall be statically or dynamically balanced. Impeller shall thread onto the pump shaft and be secured with a lock screw and conical washer.
 - c. Shafts shall be AISI 4140 alloy steel unless otherwise specified by the engineer, in which case AISI 17-4 pH stainless steel shall be supplied.
 - d. Bearings shall be anti-friction ball type of proper size and design to withstand all radial and thrust loads expected during normal operation. Bearings shall be oil lubricated from a dedicated reservoir. Pump designs which use the same oil to lubricate the bearings and shaft seal shall not be acceptable.
 - e. Each shaft seal shall be oil lubricated mechanical type. The stationary and rotating seal faces shall be tungsten titanium carbide alloy. Each mating surface shall be lapped to within three light bands flatness (35 millionths of an inch), as measured by an optical flat under monochromatic light. The stationary seal seat shall be double floating by virtue of a dual O-ring design. An external O-ring secures the stationary seat to the seal plate, and an internal O-ring holds the faces in alignment during periods of mechanical or hydraulic shock (loads which cause shaft deflection, vibration, and axial/radial movement). Elastomers shall be viton; cage and spring to be stainless steel. Seal shall be oil lubricated from a dedicated reservoir. The same oil shall not lubricate both shaft seal and shaft bearings. Seals shall be warranted in accordance with requirements listed under PART 1 - GENERAL of this section.
- 4. Adjustment of the impeller face clearances (distance between impeller and wear plate) shall be accomplished by external means.
 - a. There shall be provisions for additional clearance adjustments in the event that adjustment tolerances have been depleted from the cover plate side of the pump. The removal of stainless steel tabbed spacers from the rotating assembly side of the pump shall allow for further adjustment as described above.

- b. Clearance adjustments which requires movement of the shaft only, thereby adversely affecting seal working length or impeller back clearance, shall not be acceptable.
5. An externally removable suction check valve shall be molded Neoprene with integral steel and nylon reinforcement. A blow-out center shall protect pump casings from hydraulic shock or excessive pressure. Removal or installation of the check valve must be accomplished from the top of the lower pump casing without disturbing the suction piping or completely draining both casings. Sole function of check valve shall be to save energy by eliminating need to reprime after each pumping cycle. Pumps requiring a suction check valve to assist reprime will not be acceptable.
6. Pump shall include flange kit consisting of two ASA spool flanges that shall be one piece cast iron Class 30 suitable for attachment to suction and discharge ports. Each spool shall have one (1) 1-1/4 inch NPT and one (1) 1-1/4 inch NPT tapped hole with pipe plugs for mounting gauges or other equipment.
7. Each Pump shall be supplied with a pump casing heater that will be connected to a power supply supplied by contractor and keep the pump casing warm enough to prevent freezing during cold weather events.
8. Each pump shall be supplied with a Gorman-Rupp Check valve connected to the pump discharge flange. All other valves such as isolation valves etc. downstream of the check valve shall be supplied and installed by the Contractor.
- E. Serviceability
 1. The pump Manufacturer shall demonstrate to the engineer's satisfaction that consideration has been given to reducing maintenance costs.
 2. No special tools shall be required for replacement of any components within the pump.
- F. Drain Kit:
 1. Pumps to be supplied with a drain kit for ease of maintenance. The kit to contain a 10-foot long reinforced plastic hose with a female quick connect fitting at one end, and factory installed drain fittings in each pump. Fittings include a stainless steel pipe nipple, stainless steel bushing, stainless steel ball valve and aluminum male quick connect fitting.
- G. Spare Parts Kit:
 1. The following minimum spare parts shall be furnished with the pump station:
 - a. One (1) spare pump mechanical seal (complete with shaft sleeve)
 - b. One (1) cover plate O-Ring
 - c. One (1) rotating assembly O-Ring
 - d. One (1) set of rotating assembly spacers
- H. Automatic air release valves:
 1. A manually actuated ball style air release valve shall be furnished for each pump designed to permit the escape of air to the atmosphere during initial priming or unattended repriming cycles. Upon completion of the priming cycle or repriming cycle, the valve shall be closed to prevent recirculation. Valves which require connection to the suction line shall not be acceptable.
 2. All valve parts exposed to raw water or sewage shall be constructed of cast iron, stainless steel, or similar corrosion resistant materials. Diaphragms, if used, shall be of fabric reinforced neoprene or similar inert material.
 3. Connection of the air release valves to the station piping shall include stainless steel fittings.
- I. Supports and Thrust Blocks

1. Contractor must insure all pipes connected to the pump station are supported to prevent piping loads from being transmitted to pumps.

2.05 DRIVE UNIT

- A. Pump motors shall be horizontal TEFC, 1800 RPM, NEMA design B with cast iron frame with copper windings, induction type, with normal starting torque and low starting current characteristics, suitable for continuous service. The motors shall not overload at the design condition or at any head in the operating range as specified. Pump motor shall also be inverter duty rated for variable frequency drive operation.
- B. Drive Transmission
 1. Power to pumps transmitted V-belt drive assemblies. The sheave/belt combination shall provide the speed ratio needed to achieve the specified pump operating conditions. If new belts are required for adapting the future sheaves then they must also be supplied.
 2. Each drive assembly shall utilize at least two (2) V-belts providing minimum a combined safety factor of 1.5. Single belt drives or systems with a safety factor of less than 1.5 are not acceptable. Computation of safety factors shall be based on performance data published by the drive Manufacturer.
 3. The pump Manufacturer shall submit power transmission calculations which document the following:
 - a. Ratio of pump/motor speed.
 - b. Pitch diameter of driver and driven sheaves.
 - c. Number of belts required per drive.
 - d. Theoretical horsepower transmitted per belt, based on vendor's data.
 - e. Center distance between pump and motor shafts.
 - f. Arc-length correction factor applied to theoretical horsepower transmitted.
 - g. Service factor applied to established design horsepower.
 - h. Safety factor ratio of power transmitted/brake horsepower required.
 4. Belt guards
 - a. Pump drives to be enclosed on all sides by a guard constructed of fabricated steel or combination of materials including expanded, perforated, or solid sheet metal. No opening to a rotating member shall exceed 1/2 inch.
 - b. Guards must be completely removable without interference from any unit component, and shall be securely fastened and braced to the unit base.
 - c. Metal to be free from burrs and sharp edges. Structural joints shall be continuously welded. Rivet spacing on panels shall not exceed five inches. Tack welds shall not exceed four inch spacing.
 - d. The guard shall be finished with one coat of gray W.R. non-lift primer and one coat of orange acrylic alkyd W.R. enamel in accordance with Section 3, Color Definitions of ANSI 253.1; Safety Color Code for Marking Physical Hazards.

2.06 CLEANING

- A. Pumps, piping, and exposed steel framework shall be cleaned prior to painting. Exposed surfaces to be coated with one coat gray W.R. non-lift primer and one (1) coat **orange acrylic alkyd W.R. enamel to match existing**. Paint shall be low VOC, alkyd based, high solids, semi-gloss white enamel for optimum illumination enhancement, incorporating rust inhibitive additives. The finish coat shall be 1.0 to 1.2 MIL dry film thickness (minimum), resistant to oil mist exposure, solvent contact, and salt spray. The factory finish shall allow for over-coating and touch up after final installation. All field touch-up and surface preparation shall

be completed in accordance with the coating Manufacturer's recommendations and utilize the pump Manufacturer's standard coatings and colors.

2.07 Gauge Kit

- A. A gauge kit shall be supplied for each pump. Suction pressure must be monitored by a glycerin-filled compound gauge, and discharge pressure by a glycerin-filled pressure gauge. Gauges to be at least 4 inches in diameter, graduated in feet water column. Rated accuracy shall be 1% of full scale reading. Compound gauge shall be graduated -34 to +34 feet water column minimum. Pressure gauge to be graduated 0 to 140 feet water column minimum.
- B. Gauges to be factory mounted on a resilient panel with frame assembly secured to pumps or piping. Gauge installations shall be complete with all hoses and stainless steel fittings, including a shutoff valve for each gauge line at the point of connection to suction and discharge pipes.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Contractor shall off-load equipment at installation site using equipment of sufficient size and design to prevent injury or damage. Station Manufacturer shall provide written instruction for proper handling. Immediately after off-loading, contractor shall inspect complete pump station and appurtenances for shipping damage or missing parts. Any damage or discrepancy shall be noted in written claim with shipper prior to accepting delivery. Validate all station serial numbers and parts lists with shipping documentation. Notify the Manufacturer's representative of any unacceptable conditions noted with shipper.

3.02 INSTALLATION

- A. Contractor shall install, level, align, and lubricate pump station as indicated on project drawings. Installation must be in accordance with written instructions supplied by the Manufacturer at time of delivery.
- B. Suction pipe connections are vacuum tight. Fasteners at all pipe connections must be tight. Install pipe with supports and thrust blocks to prevent strain and vibration on pump station piping. Install and secure all service lines (level control, air release valve or pump drain lines) as required in wet well.
- C. Check motor and control data plates for compatibility to site voltage. Install and test the station ground prior to connecting line voltage to station control panel.
- D. Prior to applying electrical power to any motors or control equipment, the contractor will check all wiring for tight connection. Verify that protective devices (fuses and circuit breakers) conform to project design documents. Manually operate circuit breakers and switches to ensure operation without binding. Open all circuit breakers and disconnects before connecting utility power. Verify line voltage, phase sequence and ground before actual start-up.
- E. After all anchor bolts, piping and control connections are installed, completely fill the grout dam in the pump station base with non-shrink grout.

3.03 FIELD QUALITY CONTROL

- A. Operational Test
 - 1. Prior to acceptance by owner, an operational test of all pumps shall be conducted to determine if the installed equipment meets the purpose and intent of the specifications. Tests shall demonstrate that all equipment is mechanically, structurally, and otherwise

acceptable; it is safe and in optimum working condition; and conforms to the specified operating characteristics.

2. After construction debris and foreign material has been removed from the wet well, contractor shall supply clear water volume adequate to operate station through several pumping cycles. Observe and record operation of pumps, suction and discharge gage readings, and ampere draw. Be alert to any undue noise, vibration or other operational problems.

B. Manufacturer's Start-up Services

1. Co-ordinate station start-up with Manufacturer's technical representative. The representative or factory service technician will inspect the completed installation. He will correct or supervise correction of defects or malfunctions, and instruct operating personnel in proper operation and maintenance procedures. A minimum of two (2) days are required. A day shall be considered as eight (8) hours at the facility.

3.04 CLEANING

- A. Prior to acceptance, inspect interior and exterior of pump station for dirt, splashed material or damaged paint. Clean or repair accordingly. Remove from the job site all tools, surplus materials, scrap and debris.

3.05 PROTECTION

- A. The pump station should be placed into service immediately. If operation is delayed, drain water from pumps and piping. Open motor circuit breakers and protect station controls and interior equipment from cold and moisture.

END OF SECTION

SECTION 43 23 20

INFLUENT PUMPS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Work under this section includes, but is not limited to, furnishing and installing a factory built base mounted influent pump station as indicated on the project drawings, herein specified, as necessary for proper and complete performance.

1.02 REFERENCES

- A. Publications listed below form part of this specification to extent referenced in the text by basic designation only. Consult latest edition of publication unless otherwise noted.
 - 1. American National Std. Institute (ANSI) / American Water Works Assoc. (AWWA)
 - a. ANSI B16.1 Cast iron pipe flanges and flanged fittings.
 - b. ANSI/AWWA C115/A21.51 Cast/ductile iron pipe with threaded flanges.
 - c. ANSI 253.1 Safety Color Code for Marking Physical Hazards.
 - d. ANSI B40.1 Gages, Pressure and Vacuum.
 - e. AWWA C508 Single Swing Check Valves.
 - 2. American Society for Testing and Materials (ASTM)
 - a. ASTM A48 Gray Iron Castings.
 - b. ASTM A126 Valves, Flanges, and Pipe Fittings.
 - c. ASTM A307 Carbon Steel Bolts and Studs.
 - d. ASTM A36 Structural Steel.
 - 3. Institute of Electrical and Electronics Engineers (IEEE)
 - a. ANSI/IEEE Std 100 Standard Dictionary of Electrical Terms.
 - b. ANSI/IEEE Std 112 Test Procedure for Polyphase Induction Motors.
 - c. IEEE Std 242 Protection of Industrial and Control Power Systems.
 - 4. National Electric Code (NEC) / National Electrical Manufacturers Assoc. (NEMA)
 - a. NEC National Electric Code.
 - b. NEC 701 National Electric Code article 701.
 - c. NEMA Std MG1 Motors and Generators.
 - 5. Miscellaneous References
 - a. Hydraulic Institute Std for Centrifugal, Rotary and Reciprocating Pumps.
 - b. NMTBA and JIC Std National Machine Tool Builders Association and Joint Industrial Council Standards
 - c. ISO 9001 International Organization for Standardization.

1.03 SYSTEM DESCRIPTION

- A. Contractor shall furnish and install two (2) 40 HP factory built, individual base mounted, Gorman-Rupp Model T8A3S-B pumps. The pumps shall be complete with all equipment specified herein; factory assembled on a steel base.
- B. Principal items of equipment shall include two (2) horizontal, self-priming, centrifugal pump, check valve, air release ball valve, V-belt drive, motor. Pumps shall be mounted on individual bases.

- C. Factory built pump and skid design, including materials of construction, pump features, valves and piping, shall be in accordance with requirements listed under PART 2 - PRODUCTS of this section.

1.04 PERFORMANCE CRITERIA

- A. Pumps must be designed to handle screened, raw water sewage. Pumps shall have 6 inch diameter suction connection, and 6 inch discharge connection. Each pump shall be selected to perform under following operating conditions and shall match the performance of the existing pumps. Pumps will operate with a VFD supplied by others.
 - 1. Influent Flow – 1,215 gallons per minute at 57.3 feet of Total Dynamic Head.
- B. Site power furnished to pump station shall be 3 phase, 60 hertz, 460 volts, 4 wire, maintained within industry standards. Voltage tolerance shall be plus or minus 10 percent. Control voltage shall not exceed 132 volts.

1.05 SUBMITTALS

- A. Product Data
 - 1. Prior to fabrication, pump station Manufacturer shall submit six (6) copies of submittal data for review and approval.
 - 2. Submittal shall include shop drawings, and support data as follows: Catalog cut sheets reflecting characteristics for major items of equipment, materials of construction, major dimensions, motor and v-belt drive data, pump characteristic curves showing the design duty point capacity (GPM), head (FT), net positive suction head required (NPSHr), and hydraulic brake horsepower (BHP).
- B. Shop drawings shall provide layout of mechanical equipment and anchor bolt locations for station. Contractor piping connections and station access clearances shall be dimensioned relative to the station centerline.
- C. Operations Maintenance Manuals
 - 1. Installation shall be in accordance with written instructions provided by the pump station Manufacturer. Comprehensive instructions supplied at time of shipment shall enable personnel to properly operate and maintain all equipment supplied. Content and instructions shall assume operating personnel are familiar with pumps, motors, piping and valves, but lack experience on exact equipment supplied.
 - 2. Documentation shall be specific to the pump station supplied and collated in functional sections. Each section shall combine to form a complete system manual covering all aspects of equipment supplied by the station Manufacturer. Support data for any equipment supplied by others, even if mounted or included in overall station design, shall be provided by those supplying the equipment. Instructions shall include the following as a minimum:
 - a. Functional description of each major component, complete with operating instructions.
 - b. Instructions for operating pumps in all modes of operation.
 - c. Calibration and adjustment of equipment for initial start-up, as required for routine maintenance.
 - d. Support data for commercially available components not produced by the pump Manufacturer, but supplied in accordance with the specifications, shall be supported by literature from the prime Manufacturer and incorporated as appendices.
 - e. Mechanical layout drawing of the pump and components, prepared in accordance with good commercial practice, shall provide installation dimensions and location of all pumps, motors, and bases.

- f. Operation and maintenance instructions which rely on vendor cut-sheets and literature which include general configurations, or require operating personnel to selectively read portions of the manual shall not be acceptable. Operation and maintenance instructions must be specific to equipment supplied in accordance with these specifications.

1.06 QUALITY ASSURANCE

- A. The pumps and pump skid Manufacturer must be certified to ISO 9001 by an accredited certification agency.
- B. Upon request from the Engineer, the pump station Manufacturer shall prove financial stability and ability to produce the station within the specified delivery schedules. Evidence of facilities, equipment and expertise shall demonstrate the Manufacturer's commitment to long term customer service and product support.
- C. All internal passages, impeller vanes, and recirculation ports shall pass a 3-inch spherical solid. Smaller internal passages that create a maintenance nuisance or interfere with priming and pump performance shall not be permitted. Upon request from the Engineer, Manufacturer's certified drawings showing size and location of the recirculation port(s) shall be submitted for approval.
- D. Reprime Performance
 - 1. Consideration shall be given to the raw water service anticipated, in which debris is expected to lodge between the suction check valve and its seat, resulting in the loss of the pump suction leg, and siphoning of liquid from the pump casing to the approximate center line of the impeller. Such occurrence shall be considered normal, and the pump must be capable of automatic, unattended operation with an air release line installed.
 - 2. During unattended operation, the pump shall retain adequate liquid in the casing to insure automatic repriming while operating at its rated speed in a completely open system. The need for a suction check valve or external priming device shall not be required.
 - 3. Pump must reprime 5 vertical feet at the specified speed and impeller diameter. Reprime lift is defined as the static height of the pump suction above the liquid, while operating with only one-half of the liquid remaining in the pump casing. The pump must reprime and deliver full capacity within five minutes after the pump is energized in the reprime condition. Reprime performance must be confirmed with the following test set-up:
 - a. One (1) check valve to be installed downstream from the pump discharge flange. The check valve size shall be equal (or greater than) the pump discharge diameter.
 - b. A length of air release pipe shall be installed between pump and the discharge check valve. This line shall allow the air displacement rate anticipated at a typical pump station fitted with a ball valve style air release valve.
 - c. The pump shall have a suction check valve shall be removed. No restrictions in the pump or suction piping will prevent the siphon drop of the suction leg. Suction pipe configuration for reprime test shall incorporate a 2-foot minimum horizontal run, a 90 degree elbow and vertical run at the specified lift. Pipe size shall be equal to the pump suction diameter.
 - d. Impeller clearances shall be set as recommended in the pump service manual.
 - e. Repeatability of performance shall be demonstrated by testing five (5) consecutive reprime cycles. Full pump capacity (flow) shall be achieved within five (5) minutes during each cycle.
 - f. Liquid to be used for reprime test shall be water.

4. Upon request from the Engineer, certified reprime performance test results, prepared by the Manufacturer, and certified by a registered professional Engineer, shall be submitted for approval prior to shipment.
- E. Factory System Test
 1. All components including the pumps, motors, and controls will be tested as a complete working system at the Manufacturer's facility. Tests shall be conducted in accordance with Hydraulic Institute Standards at the specified head, capacity, rated speed and horsepower. Factory operational test shall duplicate actual performance anticipated for the complete station.
 2. Upon request from the Engineer, the operational test may be witnessed by the Engineer, and/or representatives of his choice, at the Manufacturer's facility.
- F. The Manufacturer's technical representative shall inspect the completed installation, correct or supervise the correction of any defect or malfunction, and instruct operating personnel in the proper operation and maintenance of the equipment.

1.07 MANUFACTURER'S WARRANTY

- A. The pump station Manufacturer shall warrant all equipment to be of quality construction, free of defects in material and workmanship. A written warranty shall include specific details described below.
 1. All equipment, apparatus, and parts furnished shall be warranted for one (1) year, excepting only those items that are normally consumed in service, such as light bulbs, oils, grease, packing, gaskets, O-rings, etc. The pump station Manufacturer shall be solely responsible for warranty of the station and all components.
 2. Components failing to perform as specified by the Engineer, or as represented by the Manufacturer, or as proven defective in service during the warranty period, shall be replaced, repaired, or satisfactorily modified by the Manufacturer without cost of parts or labor to the owner.
- B. It is not intended that the station Manufacturer assume liability for consequential damages or contingent liabilities arising from failure of any vendor supplied product or part which fails to properly operate, however caused. Consequential damages resulting from defects in design, or delays in delivery are also beyond the Manufacturer's scope of liability.
- C. The warranty shall become effective upon the acceptance by the purchaser or the purchaser's authorized agent or sixty (60) days after installation, whichever occurs first.

PART 2 PART 2 – PRODUCTS

2.01 UNITARY RESPONSIBILITY

- A. In order to unify responsibility for proper operation of the complete pumping station, it is the intent of these Specifications that all system components be furnished by a single supplier (unitary source). The pumping station must be of standard catalog design, fully warranted by the Manufacturer. Under no circumstances will a system consisting of parts compiled and assembled by a Manufacturer's representative or distributor be accepted.

2.02 MANUFACTURER

- A. The pump station system must be certified to ISO 9001 by an accredited certification agency.

2.03 UNIT BASE

- A. The unit base shall comprise a base plate, perimeter flange, and reinforcements. Base plate shall be fabricated of steel not less than 1/4-inch thick, and shall incorporate openings for

access to all internal cavities to permit complete grouting of unit base after installation. Perimeter flange and reinforcements shall be designed to prevent flexing or warping under operating conditions. Base plate and/or flange shall be drilled for hardware used to secure unit base to concrete pad as shown on the contract drawings. Unit base shall contain provisions for lifting the complete pump unit during shipping and installation.

2.04 PUMP DESIGN

- A. The Manufacturer of the pumps must be ISO 9001:2008 revision certified, with scope of registration including design control and service after sales activities.
- B. Pump shall be horizontal, self-priming centrifugal type, designed specifically for handling raw unscreened domestic sanitary sewage or industrial waste. Pump solids handling capability and performance criteria shall be in accordance with requirements listed under PART 1 - GENERAL of this section.
- C. The cover plates and rotating assemblies shall be interchangeable between both casings.
- D. Materials and Construction Features
 - 1. Pump casings shall be cast iron Class 30 with integral volute scroll. Casing shall incorporate following features:
 - a. Mounting feet sized to prevent tipping or binding when pump is completely disassembled for maintenance.
 - b. Fill port cover plate, 3-1/2 inch diameter, shall be opened after loosening a positive lock clamp bar assembly. In consideration for safety, capscrew threads must provide slow release of pressure, and the clamp bar shall be retained by detente lugs. A non-metallic gasket shall prevent adhesion of the fill port cover to the casing while assuring a reliable seal.
 - c. Lower casing drain plug shall be at least 1-1/4 inch NPT to insure complete and rapid draining.
 - d. Liquid volume and recirculation port design shall be consistent with performance criteria listed under PART 1 - GENERAL of this section.
 - 2. Cover plates shall be cast iron Class 30. Design must incorporate the following maintenance features:
 - a. Retained by hand nuts for complete access to pump interior. Cover plate removal must provide ample clearance for removal of stoppages, and allow service to the impeller, seal, wear plate or check valve without removing suction or discharge piping.
 - b. Self-Cleaning Wearplate
 - i. Replaceable wear plates secured to the cover plates by weld studs and nuts shall be AISI 1015 HRS. Wear plates shall be self-cleaning design ensuring that debris is cleared away and does not collect on the impeller vanes.
 - ii. The nature of the conveyed medium poses significant challenges to the continuous operation of the pump. Of particular concern is the clogging of the impeller by debris in the pumped medium including but not limited to long rags, fibers, and similar debris which are able to wrap around the impeller vanes, stick to the center of the vanes or hub, or lodge within the spaces between the impeller and the housing.
 - iii. The wearplate shall have one or more notches and/or recesses provided along a common diameter of the wearplate to disturb and dislodge any solids which might otherwise remain on the impeller in dynamic operation. Clusters of notches and/or recesses may also be provided.
 - c. In consideration for safety, a pressure relief valve shall be supplied in each pump.
 - d. O-rings of Buna-N material shall seal each cover plate to pump casings.

- e. Pusher bolt capability to assist in removal of cover plates. Pusher bolt threaded holes shall be sized to accept same retaining capscrews as used in rotating assemblies.
- 3. Each rotating assembly, which includes impeller, shaft, mechanical shaft seal, lip seals, bearings, seal plate and bearing housing, must be removable as a single unit without disturbing the pump casing or piping. Design shall incorporate the following features:
 - a. Seal plates and bearing housings shall be cast iron Class 30. Anti-rotation ribs shall be cast into the seal plates to reduce internal wear and maximize component life. Separate oil filled cavities, vented to atmosphere, shall be provided for shaft seal and bearings. Cavities must be cooled by the liquid pumped. Three lip seals will prevent leakage of oil.
 - i. Each bearing cavity shall have an oil level sight gauge and fill plug check valve. The clear sight gauge shall provide easy monitoring of the bearing cavity oil level and condition of oil without removal of the fill plug check valve. The check valve shall vent the cavity but prevent introduction of moist air to the bearings.
 - ii. Each seal cavity shall have an oil level sight gauge and fill/vent plug. The clear sight gauge shall provide easy monitoring of the seal cavity oil level and condition of oil without removal of the fill/vent plug.
 - iii. Double lip seals shall provide an atmospheric path providing positive protection of bearings, with capability for external drainage monitoring.
 - b. Impellers shall be ductile iron, two vane, semi-open, non-clog, with integral pump out vanes on the back shroud. Impellers shall be statically or dynamically balanced. Impeller shall thread onto the pump shaft and be secured with a lockscrew and conical washer.
 - c. Shafts shall be AISI 4140 alloy steel unless otherwise specified by the Engineer, in which case AISI 17-4 pH stainless steel shall be supplied.
 - d. Bearings shall be anti-friction ball type of proper size and design to withstand all radial and thrust loads expected during normal operation. Bearings shall be oil lubricated from a dedicated reservoir. Pump designs which use the same oil to lubricate the bearings and shaft seal shall not be acceptable.
 - e. Each shaft seal shall be oil lubricated mechanical type. The stationary and rotating seal faces shall be tungsten titanium carbide alloy. Each mating surface shall be lapped to within three light bands flatness (35 millionths of an inch), as measured by an optical flat under monochromatic light. The stationary seal seat shall be double floating by virtue of a dual O-ring design. An external O-ring secures the stationary seat to the seal plate, and an internal O-ring holds the faces in alignment during periods of mechanical or hydraulic shock (loads which cause shaft deflection, vibration, and axial/radial movement). Elastomers shall be viton; cage and spring to be stainless steel. Seal shall be oil lubricated from a dedicated reservoir. The same oil shall not lubricate both shaft seal and shaft bearings. Seals shall be warranted in accordance with requirements listed under PART 1 - GENERAL of this section.
- 4. Adjustment of the impeller face clearances (distance between impeller and wear plate) shall be accomplished by external means.
 - a. There shall be provisions for additional clearance adjustments in the event that adjustment tolerances have been depleted from the cover plate side of the pump. The removal of stainless steel tabbed spacers from the rotating assembly side of the pump shall allow for further adjustment as described above.

- b. Clearance adjustments which requires movement of the shaft only, thereby adversely affecting seal working length or impeller back clearance, shall not be acceptable.
- 5. An externally removable suction check valve shall be molded Neoprene with integral steel and nylon reinforcement. A blow-out center shall protect pump casings from hydraulic shock or excessive pressure. Removal or installation of the check valve must be accomplished from the top of the lower pump casing without disturbing the suction piping or completely draining both casings. Sole function of check valve shall be to save energy by eliminating need to reprime after each pumping cycle. Pumps requiring a suction check valve to assist reprime will not be acceptable.
- 6. Pump shall include flange kit consisting of two ASA spool flanges that shall be one piece cast iron Class 30 suitable for attachment to suction and discharge ports. Each spool shall have one (1) 1-1/4 inch NPT and one (1) 1-1/4 inch NPT tapped hole with pipe plugs for mounting gauges or other equipment.
- 7. Each Pump shall be supplied with a pump casing heater that will be connected to a power supply supplied by contractor and keep the pump casing warm enough to prevent freezing during cold weather events.
- 8. Each pump shall be supplied with a Gorman-Rupp Check valve connected to the pump discharge flange. All other valves such as isolation valves etc. downstream of the check valve shall be supplied and installed by the Contractor.
- E. Serviceability
 - 1. The pump Manufacturer shall demonstrate to the Engineer's satisfaction that consideration has been given to reducing maintenance costs.
 - 2. No special tools shall be required for replacement of any components within the pump.
- F. Drain Kit:
 - 1. Pumps to be supplied with a drain kit for ease of maintenance. The kit to contain a 10-foot long reinforced plastic hose with a female quick connect fitting at one end, and factory installed drain fittings in each pump. Fittings include a stainless steel pipe nipple, stainless steel bushing, stainless steel ball valve and aluminum male quick connect fitting.
- G. Spare Parts Kit:
 - 1. The following minimum spare parts shall be furnished with the pump station:
 - a. One (1) spare pump mechanical seal (complete with shaft sleeve)
 - b. One (1) cover plate O-Ring
 - c. One (1) rotating assembly O-Ring
 - d. One (1) set of rotating assembly spacers
- H. Automatic air release valves:
 - 1. A manually actuated ball style air release valve shall be furnished for each pump designed to permit the escape of air to the atmosphere during initial priming or unattended repriming cycles. Upon completion of the priming cycle or repriming cycle, the valve shall be closed to prevent recirculation. Valves which require connection to the suction line shall not be acceptable.
 - 2. All valve parts exposed to raw water or sewage shall be constructed of cast iron, stainless steel, or similar corrosion resistant materials. Diaphragms, if used, shall be of fabric reinforced neoprene or similar inert material.
 - 3. Connection of the air release valves to the station piping shall include stainless steel fittings.
- I. Supports and Thrust Blocks

1. Contractor must insure all pipes connected to the pump station are supported to prevent piping loads from being transmitted to pumps.

2.05 DRIVE UNIT

- A. Pump motors shall be horizontal TEFC, 1800 RPM, NEMA design B with cast iron frame with copper windings, induction type, with normal starting torque and low starting current characteristics, suitable for continuous service. The motors shall not overload at the design condition or at any head in the operating range as specified. Pump motor shall also be inverter duty rated for variable frequency drive operation.
- B. Drive Transmission
 1. Power to pumps transmitted V-belt drive assemblies. The sheave/belt combination shall provide the speed ratio needed to achieve the specified pump operating conditions. If new belts are required for adapting the future sheaves then they must also be supplied.
 2. Each drive assembly shall utilize at least two (2) V-belts providing minimum a combined safety factor of 1.5. Single belt drives or systems with a safety factor of less than 1.5 are not acceptable. Computation of safety factors shall be based on performance data published by the drive Manufacturer.
 3. The pump Manufacturer shall submit power transmission calculations which document the following:
 - a. Ratio of pump/motor speed.
 - b. Pitch diameter of driver and driven sheaves.
 - c. Number of belts required per drive.
 - d. Theoretical horsepower transmitted per belt, based on vendor's data.
 - e. Center distance between pump and motor shafts.
 - f. Arc-length correction factor applied to theoretical horsepower transmitted.
 - g. Service factor applied to established design horsepower.
 - h. Safety factor ratio of power transmitted/brake horsepower required.
 4. Belt guards
 - a. Pump drives to be enclosed on all sides by a guard constructed of fabricated steel or combination of materials including expanded, perforated, or solid sheet metal. No opening to a rotating member shall exceed 1/2 inch.
 - b. Guards must be completely removable without interference from any unit component, and shall be securely fastened and braced to the unit base.
 - c. Metal to be free from burrs and sharp edges. Structural joints shall be continuously welded. Rivet spacing on panels shall not exceed five inches. Tack welds shall not exceed four inch spacing.
 - d. The guard shall be finished with one coat of gray W.R. non-lift primer and one coat of orange acrylic alkyd W.R. enamel in accordance with Section 3, Color Definitions of ANSI 253.1; Safety Color Code for Marking Physical Hazards.

2.06 CLEANING

- A. Pumps, piping, and exposed steel framework shall be cleaned prior to painting. Exposed surfaces to be coated with one coat gray W.R. non-lift primer and one (1) coat **orange acrylic alkyd W.R. enamel to match existing**. Paint shall be low VOC, alkyd based, high solids, semi-gloss white enamel for optimum illumination enhancement, incorporating rust inhibitive additives. The finish coat shall be 1.0 to 1.2 MIL dry film thickness (minimum), resistant to oil mist exposure, solvent contact, and salt spray. The factory finish shall allow for over-coating and touch up after final installation. All field touch-up and surface preparation shall

be completed in accordance with the coating Manufacturer's recommendations and utilize the pump Manufacturer's standard coatings and colors.

2.07 Gauge Kit

- A. A gauge kit shall be supplied for each pump. Suction pressure must be monitored by a glycerin-filled compound gauge, and discharge pressure by a glycerin-filled pressure gauge. Gauges to be at least 4 inches in diameter, graduated in feet water column. Rated accuracy shall be 1% of full scale reading. Compound gauge shall be graduated -34 to +34 feet water column minimum. Pressure gauge to be graduated 0 to 140 feet water column minimum.
- B. Gauges to be factory mounted on a resilient panel with frame assembly secured to pumps or piping. Gauge installations shall be complete with all hoses and stainless steel fittings, including a shutoff valve for each gauge line at the point of connection to suction and discharge pipes.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Contractor shall off-load equipment at installation site using equipment of sufficient size and design to prevent injury or damage. Station Manufacturer shall provide written instruction for proper handling. Immediately after off-loading, contractor shall inspect complete pump station and appurtenances for shipping damage or missing parts. Any damage or discrepancy shall be noted in written claim with shipper prior to accepting delivery. Validate all station serial numbers and parts lists with shipping documentation. Notify the Manufacturer's representative of any unacceptable conditions noted with shipper.

3.02 INSTALLATION

- A. Contractor shall install, level, align, and lubricate pump station as indicated on project drawings. Installation must be in accordance with written instructions supplied by the Manufacturer at time of delivery.
- B. Suction pipe connections are vacuum tight. Fasteners at all pipe connections must be tight. Install pipe with supports and thrust blocks to prevent strain and vibration on pump station piping. Install and secure all service lines (level control, air release valve or pump drain lines) as required in wet well.
- C. Check motor and control data plates for compatibility to site voltage. Install and test the station ground prior to connecting line voltage to station control panel.
- D. Prior to applying electrical power to any motors or control equipment, the contractor will check all wiring for tight connection. Verify that protective devices (fuses and circuit breakers) conform to project design documents. Manually operate circuit breakers and switches to ensure operation without binding. Open all circuit breakers and disconnects before connecting utility power. Verify line voltage, phase sequence and ground before actual start-up.
- E. After all anchor bolts, piping and control connections are installed, completely fill the grout dam in the pump station base with non-shrink grout.

3.03 FIELD QUALITY CONTROL

- A. Operational Test
 - 1. Prior to acceptance by owner, an operational test of all pumps shall be conducted to determine if the installed equipment meets the purpose and intent of the specifications. Tests shall demonstrate that all equipment is mechanically, structurally, and otherwise

acceptable; it is safe and in optimum working condition; and conforms to the specified operating characteristics.

2. After construction debris and foreign material has been removed from the wet well, contractor shall supply clear water volume adequate to operate station through several pumping cycles. Observe and record operation of pumps, suction and discharge gage readings, and ampere draw. Be alert to any undue noise, vibration or other operational problems.

B. Manufacturer's Start-up Services

1. Co-ordinate station start-up with Manufacturer's technical representative. The representative or factory service technician will inspect the completed installation. He will correct or supervise correction of defects or malfunctions, and instruct operating personnel in proper operation and maintenance procedures. A minimum of two (2) days are required. A day shall be considered as eight (8) hours at the facility.

3.04 CLEANING

- A. Prior to acceptance, inspect interior and exterior of pump station for dirt, splashed material or damaged paint. Clean or repair accordingly. Remove from the job site all tools, surplus materials, scrap and debris.

3.05 PROTECTION

- A. The pump station should be placed into service immediately. If operation is delayed, drain water from pumps and piping. Open motor circuit breakers and protect station controls and interior equipment from cold and moisture.

END OF SECTION

SECTION 43 25 00

PLANT DRAIN PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. Work covered in this Section includes furnishing all labor, equipment and materials required to install the variable frequency drive submersible non-clog pumps complete with motors, permanent discharge elbows, guide bars, upper and lower guide bar brackets, power cables, lifting chains, pump controls, pressure transducers, anchor bolts, spare parts and other accessories including all necessary labor, supervision, materials, tools, and appurtenances.
- B. Submersible pump hatches shall be supplied by the pump Manufacturer.

1.02 SYSTEM DESCRIPTION

A. PLANT DRAIN PUMP STATION

- 1. Furnish and install two (2) VFD, submersible non-clog wastewater pumps, equipped with a 20 HP submersible electric motor, connected for operation on 460 volts, 3 phase, 60 Hz, with submersible cable (SUBCAB) suitable for submersible pump applications. The power cable shall be sized according to NEC and ICEA standards and also meet with P-MSHA approval. Include painting, field testing and additional services of the equipment supplier.
- 2. Manufacturer: Flygt or Engineer approved alternate.
- 3. Pumps shall be the product of the same manufacturer to ensure maximum compatibility and interchangeability of parts.
- 4. The pump Manufacturer shall coordinate pump controls with the controls for the control valves in the pump discharge piping so that complete and operable system is achieved.
- 5. The Contractor will be responsible for all incidental details and for any special construction necessary to complete the work in an acceptable manner.

1.03 QUALITY ASSURANCE

- A. Equipment: New, suitable for the conditions of service to which they will be subject, and equal to the best of their respective classes.
- B. Grade and quality shall meet the applicable cited specifications and standards.

1.04 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Submit Manufacturer's data including materials of construction and equipment weight, motor data, performance curves, shop drawings.
- C. Performance curves shall depict:

1. Head plotted against capacity.
 2. Speed (RPM).
 3. Combined weight of pump and motor.
 4. Impeller diameter.
 5. Area of the eye of impeller in square inches.
 6. Clearly marked operation points.
 7. Maximum horsepower motor that could be utilized.
 8. Shut-off head.
 9. Kilowatt usage at design conditions.
 10. Horsepower efficiency.
 11. NPSH requirements over the manufacturers recommended range of operation.
- D. Shop Drawings:
1. Submit certified shop and installation drawings showing materials, details of construction, dimensions, control details and electrical wiring diagrams, and performance data.
 2. Show complete information concerning parts, accessories and appliances, piping, valves, motors, conduit, wiring and equipment, methods and material of construction, location and installation, support, anchorage and connections and wiring diagrams, surface finishes and other details.
- E. Test Reports:
1. Written factory test results.
 2. Written field test results.
- F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- G. Extended warranty as specified in this Section.
- H. Product Data: Submit manufacturer's product data for system materials and component equipment.
- I. Operation and Maintenance Data: Submit equipment operation and maintenance manuals.
1. Include periodic maintenance recommendations.
 2. Include list of equipment, accessories and tools needed to maintain and calibrate equipment.
 3. Clearly identify or number parts to facilitate ordering of replacements.
 4. Include descriptions of operational control devices and their specific functions.

1.05 QUALIFICATIONS

- A. The equipment to be furnished hereunder shall be made by a manufacturer regularly engaged in such work, and who has furnished similar installations and had them in successful and continuous operation for a period of ten (10) years.

1.06 PATENTS AND CLAIMS

- A. Under this Section the Contractor shall be responsible for all patents and licenses relating to the furnishing and use of the equipment supplied hereunder and to any special construction inherent to the installation of said equipment, and the Contractor shall pay all patent fees and

license costs and shall indemnify the Owner and the Engineer from all claims pertaining thereto in accordance with these Specifications.

1.07 FACTORY TESTS

- A. Each pump to be delivered under this Section shall be tested for performance at the pump manufacturer's factory to determine head versus capacity, efficiencies, and kilowatt draw required for the operating points that are specified. All tests shall be run in accordance with the latest edition of the American Hydraulic Institute Standards and at the appropriate voltage and frequency. Testing shall also include, but not be limited to, the following:
 - 1. Head vs. flow with five (5) equally spaced points including shutoff and maximum flow shall be certified.
 - 2. The input Kw, speed, power factor, no load current, and torque characteristics shall be certified.
 - 3. Impeller, motor rating and electrical connections shall first be checked for compliance to the specifications.
 - 4. A motor and cable insulation test for moisture content or insulation defects shall be made.
 - 5. Prior to submergence, the pump shall be run dry to establish correct rotation and mechanical integrity.
 - 6. The pump shall be run for 30 minutes submerged a minimum of 6 feet under water.
 - 7. After the operational test described in line No. 6, the insulation test described in line No. 4 shall be performed again.
 - 8. After testing, the pump shall be inspected to insure that the pump maintains full watertight integrity.
- B. A written report stating the tests have successfully been completed and providing the results of the test shall be provided for each pump. The pump manufacturer shall also certify that similar tests have been conducted on pumps of a similar size for a period of not less than five (5) years.

PART 2 PRODUCTS

2.01 PUMP REQUIREMENTS

- A. Pumps shall be the submersible type specifically designed for raw sewage containing solids and stringy materials.
- B. The pumps shall be capable of handling raw, unscreened sewage while running in a continuous submerged condition.
- C. The pump shall operate without clogging or fouling caused by materials in the pumped fluid at any operating condition within the range of service specified.
- D. The pump shall be designed to operate without cavitation over the full range of operating conditions.
- E. The pump head capacity curve shall slope in one continuous curve with no point of reverse slope inflection.

- F. Pumps shall be designed for continuous operation under submerged, partially submerged or totally dry conditions without damage to the pump or motor.
- G. The complete pumping unit shall be designed to operate without overload on any component at any point along the pump's entire operating curve.
- H. Without derating the motor, the pumps shall be able to pump continuously with the minimum water level at the bottom of the motor housing, under full load, without the need of spray systems or air moving equipment.
- I. The motors' horsepower shall be adequate so that each pump is non-overloading throughout its entire pump performance curve from shut-off through run-out.
- J. Pumping Requirements:
 - 1. Plant Drain Pump Station: 800 gallons per minute at 42.7 ft. TDH
- K. Plant Drain Pump Station Equipment to be furnished:
 - 1. Pump and motor – two (2) units
 - 2. Base elbow with 6-inch diameter discharge connection – two (2) units
 - 3. 2-inch diameter Schedule 40, Type 304 stainless steel guide rails – two (2) sets
 - 4. Intermediate guide rail brackets – two (2) each for each pair of guide rails
 - 5. Upper guide rail bracket – one (1) for each pair of guide rails
 - 6. Anchor bolts (304 stainless steel) – one (1) set for each base elbow
 - 7. Control system – reference Division 26 and Electrical Plans
 - 8. Electrical – reference Division 26 and Electrical Plans

2.02 PUMP CONSTRUCTION

- A. Major pump components shall be of grey cast iron, ASTM A48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities.
- B. The lifting handle shall be of stainless steel.
- C. All exposed nuts and bolts shall be of stainless steel construction.
- D. All surfaces, excluding stainless steel or brass, shall be coated as specified in accordance with the manufacturer's recommendations.
- E. Sealing design shall incorporate metal-to-metal contact between machined surfaces.
 - 1. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile rubber O-rings.
 - 2. Fittings will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit.

2.03 MOTOR PROTECTION

- A. The motor protection systems shall consist of thermal and leakage sensors.
 - 1. The stators in each pump shall be equipped with three (3) thermal switches to monitor stator temperature and protect the pumps from overheating.

2. The thermal switches shall be embedded in the end coils of the stator winding (one (1) switch in each stator phase) and shall be used in the conjunction with external motor overload protection and wired to the control panel.
 3. Should high temperature occur, the thermal switches shall open and activate an alarm.
- B. The lower bearing housing in each pump shall include an independent thermal sensor to monitor the bearing temperature.
1. If a high temperature occurs, the sensor shall activate an alarm.
- C. A leakage sensor shall be available to detect water in the stator chambers.
1. The monitoring system shall consist of a float switch which when activated, the sensor shall activate an alarm.

2.04 CABLE SEAL

- A. The flexible power cables for submersible pumps shall include an equipment grounding conductor to the submersible pump frame and shall be sized according to NEC and ICEA Standards.
1. The cable entry water seal design shall preclude specific torque requirements to insure a watertight and submersible seal.
 2. The cable entry shall comprise of dual cylindrical elastomer grommets, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter.
 3. The grommets shall be compressed by the cable entry unit, thus providing a strain relief function, separate from the function of sealing the cable.
 4. The assembly shall provide ease of changing the cable when necessary using the same entry seal.
 5. The cable entry junction chamber and motor shall be sealed from each other, which shall isolate the stator housing from foreign material gaining access through the pump top.
 6. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.05 MOTOR

- A. The pump motor shall be a NEMA B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber.
1. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356°F). The stator shall be insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95%.
 2. The motor shall be inverter duty rated in accordance with NEMA MG1, Part 31.
 3. The stator shall be heat-shrink fitted into the cast iron stator housing.
 4. The use of multiple step dip and bake-type stator insulation process is not acceptable.
 5. The use of pins, bolts, screws or other fastening devices used to locate or hold the stator and that penetrate the stator housing are not acceptable.
 6. The motor shall be designed for continuous duty while handling pumped media of up to 104°F.
 7. The motor shall be capable of no less than 30 evenly spaced starts per hour.
 8. The rotor bars and short circuit rings shall be made of aluminum.
 9. Three (3) thermal switches shall be embedded in the stator end coils, one (1) per phase winding, to monitor the stator temperature. These thermal switches shall be used in

- conjunction with and supplemental to external motor overload protection and shall be connected to the motor control panel.
10. Motor horsepower shall be sufficient so that the pump is non-overloading throughout its entire performance curve, from shut-off to run-out.
 11. The submersible electrical cable shall be of sufficient length to reach the junction box.
 12. Capable of continuous submergence underwater without losses of watertight integrity to a depth of 65 feet.
 13. Motor and pump designed by the same manufacturer.
- B. The junction chamber shall be sealed off from the stator housing and shall contain a terminal board for connection of power and pilot sensor cables using threaded compression type terminals. The use of wire nuts or crimp-type connectors is not acceptable. The motor and the pump shall be produced by the same manufacturer.
- C. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15.
1. The motor shall have a voltage tolerance of plus or minus 10%.
 2. The motor shall be designed for operation up to 104°F (40°C) ambient and shall have a NEMA Class B maximum operating temperature rise of 176°F (80°C).
 3. A performance chart shall be provided showing curves for motor torque, current, power factor, input/output kW and efficiency.
 4. This chart shall also include data on starting and no-load characteristics.
- D. An electric moisture detection system shall be provided in each pump.
1. The leakage sensor shall be located in the motor housing and wired through the junction box to the control panel.
 2. Any indication of moisture present shall activate a visual warning that leakage has occurred.

2.06 BEARINGS

- A. The integral pump/motor shaft shall rotate on two bearings.
1. Bearings shall be sealed and permanently grease lubricated with high temperature grease.
 2. The upper motor bearing shall be a single ball type bearing to handle radial loads.
 3. The lower bearing shall be a two row angular contact ball bearing to handle the thrust and radial forces.
 4. The minimum L10 bearing life shall be 50,000 hours at any usable portion of the pump curve.

2.07 MECHANICAL SEALS

- A. Each pump shall be provided with a positively driven dual, tandem mechanical shaft seal system consisting of two seal sets, each having an independent spring.
1. The lower primary seal, located between the pump and seal chamber, shall contain one stationary and one positively driven rotating corrosion resistant tungsten-carbide ring.
 2. The upper secondary seal, located between the seal chamber and the seal inspection chamber shall be a leakage-free seal.
 3. The upper seal shall contain one stationary and one positively driven rotating corrosion resistant tungsten-carbide seal ring.

4. The rotating seal ring shall have small back-swept grooves laser inscribed upon its face to act as a pump as it rotates, returning any fluid that should enter the dry motor chamber back into the lubricant chamber.
 5. All seal rings shall be individual solid sintered rings.
 6. Each seal interface shall be held in place by its own spring system.
 7. The seals shall not depend upon direction of rotation for sealing.
 8. Mounting of the lower seal on the impeller hub is not acceptable.
 9. Shaft seals without positively driven rotating members or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces are not acceptable.
 10. The seal springs shall be isolated from the pumped media to prevent materials from packing around them, limiting their performance.
- B. Each pump shall be provided with a lubricant chamber for the shaft sealing system.
1. The lubricant chamber shall be designed to prevent overfilling and shall provide capacity for lubricant expansion.
 2. The seal lubricant chamber shall have one drain and one inspection plug that are accessible from the exterior of the motor unit.
 3. The seal system shall not rely upon the pumped media for lubrication.
 4. The seal lubricant shall be non-hazardous.
- C. The area about the exterior of the lower mechanical seal in the cast iron housing shall have cast in an integral concentric spiral groove.
1. This groove shall protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.
- D. A separate seal leakage chamber shall be provided so that any leakage that may occur past the upper, secondary mechanical seal will be captured prior to entry into the motor stator housing.
1. Such seal leakage shall not contaminate the motor lower bearing.
 2. The leakage chamber shall be equipped with a float type switch that will signal if the chamber should reach 50% capacity.

2.08 PUMP SHAFT

- A. The pump and motor shaft shall be a single piece unit.
- B. The pump shaft is an extension of the motor shaft. Shafts using mechanical couplings shall not be acceptable.
- C. The shaft shall be stainless steel – ASTM A479 S43100-T.
- D. Shaft sleeves will not be acceptable.
- E. The pump shaft shall be completely isolated from the pumped media.

2.09 IMPELLER

- A. The impeller shall be of ASTM A-532 (Alloy III A) 25% chrome cast iron, dynamically balanced, semi-open, multi-vane, back swept, screw-shaped, non-clog design.

- B. The impeller leading edges shall be mechanically self-cleaned automatically upon each rotation as they pass across a spiral groove located on the volute suction.
- C. The leading edges of impeller shall be hardened to Rc 60 and shall be capable of handling solids, fibrous materials, heavy sludge and other matter normally found in wastewater.
- D. The screw shape of the impeller inlet shall provide an inducing effect for the handling of up to 5% sludge and rag-laden wastewater.
- E. The impeller to volute clearance shall be readily adjustable by the means of a single trim screw.
- F. The impellers shall be locked to the shaft, held by an impeller bolt and shall be coated with alkyd resin primer.

2.10 VOLUTE/SUCTION COVER

- A. The pump volute shall be a single piece gray cast iron, ASTM A-48, Class 35B, non-concentric design with smooth passages of sufficient size to pass any solids that may enter the impeller.
- B. Minimum inlet and discharge size shall be as specified.
- C. The volute shall have a replaceable suction cover insert ring in which are cast spiral-shaped, sharp-edged groove(s).
- D. The spiral groove(s) shall provide trash release pathways and sharp edge(s) across which each impeller vane leading edge shall cross during rotation so to remain unobstructed.
- E. The insert ring shall be ASTM A-532 (Alloy III A) 25% chrome cast iron) and provide effective sealing between the multi-vane semi-open impeller and the volute housing.

2.11 GUIDE SYSTEM

- A. Provide pumps with a guide system to allow easy removal of the pumps without entering the wet well.
 - 1. Provide two (2) guide bars extending from the top slab of the pump station to the discharge connection of each pump to assist in raising and lowering the pump unit.
 - 2. Bolt the discharge connection to the floor to serve as a lower attachment for the guide bars.
 - 3. The working load of the lifting system shall be 50% greater than the pump unit weight.
- B. Guide the pump unit on the bars by a guide bracket which shall be an integral part of the pump.
- C. Fit each pump with sufficient length of stainless steel chain capable of lifting the pump and motor.
- D. Include the "grip eye" lift and slings with the guide system.
- E. Provide necessary fittings and eye bolts.

F. The guide system shall be fully warranted for ten (10) years.

2.12 PUMP CONTROLS

A. Reference Electrical Plans

2.13 ELECTRICAL WORK

A. Reference Electrical Plans

2.14 TOOLS AND LUBRICANTS

- A. Furnish a complete set of any special tools required for the maintenance and operation of this equipment, as designated by the equipment manufacturer.
- B. Furnish a one (1) year supply of each type of lubricant required for each piece of equipment and one grease gun for each type lubricant required under this Section.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Furnish and install the pumps at the locations indicated in the Drawings and in accordance with the pump manufacturer's specification and recommendations.
- B. Mount discharge elbows on concrete pedestals prepared for the elbows, and over anchor bolts set in the concrete.
- C. Set pump pedestals at proper elevation, location and alignment, and level. Grout in, filling the entire underside of the base.
 - 1. Grout: According to manufacturer's recommendations and as specified in Section 03 60 00 - Grouting.
- D. Grout all piping to the pump connections in a manner that will prevent the possibility of applying any loads or stresses to pump connections.

3.02 ANCHOR BOLTS AND FASTENERS

- A. Furnish anchor bolts, nuts, washers, and fasteners with the equipment herein specified and set in conformance with templates or drawings also supplied by the manufacturer.
- B. Install anchor bolts, studs, washers, nuts and fasteners required to complete the Work.

3.03 PAINTING

- A. Shop prime mild steel parts not buried in concrete, cadmium plated, galvanized, or plastic covered parts with one (1) coat of paint recommended as compatible with finish coats by the manufacture whose paint is to be used for field painting unless otherwise directed by Engineer.

- B. Painting of stainless steel, aluminum, brass, bronze, galvanized or cadmium plated steel, and plastic covered parts is not allowed.
- C. Protect machined and finished surfaces with a suitable lubricant to prevent rusting.
- D. Remedy all damage to shop coatings after installation of equipment, and to the satisfaction of the Engineer.

3.04 FIELD TESTS

- A. The pumps installed shall be tested at start-up by the Manufacturer.
- B. Run hydraulic, mechanical and electrical tests to ensure proper installation, operation, and maintenance of the pumps.
- C. Check for the following:
 - 1. Compliance with operating requirements.
 - 2. Correct rotation before mounting to the discharge connection.
 - 3. Balanced voltage and current.
 - 4. Proper seating of the pump to the discharge connection.
 - 5. Assurance that the connection between the pump and discharge connection does not leak.
 - a. If the connection leaks, the discharge elbow shall be replaced by the pump manufacturer at no cost to the supplying Contractor or Owner.

3.05 ADJUSTING, TESTING, TRAINING AND ADDITIONAL SERVICES

- A. Fully test each pumping unit with motors on water at the pump Manufacturer's works to establish that all rating conditions have been met.
 - 1. Make all remedial work necessary on any or all pumps should they fail to meet the conditions specified at no extra compensation.
 - 2. Retest. Failure to meet the specified conditions after remedial work has been performed may be cause for rejection of the pumps.
- B. Submit six (6) certified copies of tests on pumps for acceptance by Engineer before shipment.
- C. On completion of the work, the entire pumping equipment shall be lined up, operated and adjusted by qualified representatives of the pump and control manufacturers, and under the intended operating conditions, and shall be left in first class, satisfactory, operating conditions, ready for continuous and satisfactory operation.
- D. Furnish all power, oil fuses and other supplies for the field testing of the pumps, equipment, controls, and appurtenances, together with the services of the manufacturer's representatives.
- E. Provide a factory trained representative to provide the required operation and maintenance instructions to plant personnel for a period of not less than two (2) days.

3.06 PUMP WARRANTY

- A. Provide documentation from pump manufacturer demonstrating warranty of the pumps being supplied to the owner against defects in materials and workmanship for a period of five (5) years or 15,000 hours under a Municipal Wastewater Permanent Installation Warranty.
- B. Provide documentation from pump manufacturer showing that the pump manufacturer fully warrants the guide system supplied for a period of ten (10) years.

END OF SECTION

SECTION 46 21 24

MICRO BAR SCREEN

PART 1 GENERAL

1.01 SUMMARY

- A. Manufacture and provide one (1) fine bar screen, one (1) compactor washer, one (1) control panel and one (1) set of related accessories required for fully automatic operation as indicated on the included drawings and specified herein.
- B. One (1) Mechanically Cleaned Bar Screen shall be used at the headworks of the wastewater treatment plant to remove debris including wipes, rags, hair, plastics and other foreign objects from the influent sewage. The screens shall not become blinded by any of these items or by fats, oil and grease during operation. Screenings shall be continuously discharged by a mechanical scraper arm to the screw compactor located at grade.
- C. Entire screen maintenance is possible from grade. No ladders or platforms shall be needed for any portion of the maintenance i.e., greasing bearings or tightening chains.
- D. Design Criteria
 - 1. Model Number: MB12100
 - 2. Type: Mechanically Cleaned Tapered Bar Screen
 - 3. Screen Opening: 3 millimeters
 - 4. Peak Flow: 3.5 MGD
 - 5. Channel Depth: 3'-6"
 - 6. Channel Width: 5'
 - 7. Screen Angle: 75 degrees
 - 8. Motor Rating: 1/2 HP, 3 phase, 230/460 Volt, 60 Hz
 - 9. Wastewater: Standard Municipal; TSS 200-500 mg/L
 - 10. Material: Main Frame, Micro Bar, Head Shaft, Rake Chain & Rake, Tail Shaft, Rake Chain Sprocket: Type 304 stainless steel
 - 11. Screening Bar Array: Tapered Bars
 - 12. Head and Tail Sprockets: Machined, heavy duty
 - 13. Head Shaft Bearings: Heavy duty, grease-lubricated, adjustable, take-up bearing assemblies
 - 14. Tail Shaft Bearings: Heavy duty, lubrication-free, sealed graphite immersed phenol resin bushings
 - 15. Rakes: Penetrating rake teeth with max. interval of 48 inches

16. Rake Hinges:.....Cushion spring mounted with 60 to 90 degrees backwards rotation capability
17. Chain:.....Roller Chain
18. Chain Tension: Zero static tension
19. Chain Guides: UV stabilized UHMW
20. Rake Scraper:.....Installed of discharge chute (Type 304 stainless steel)
21. Discharge: Fully enclosed to compactor washer
22. Certification: ISO 9001:2008 and ISO 14001
23. Level Sensors:.....Included

1.02 QUALITY ASSURANCE

- A. Manufacturer: Shall furnish a fully functioning screen as dictated by the accepted Scope of Supply. Manufacturer shall have produced similar process configurations for a period of at least five (5) years.
- B. Manufacturer's Services: Manufacturer's personnel, for the equipment specified herein, shall be present at the job site for a minimum of two (2) days, travel time excluded, for inspection of installation, certification of field testing and adjustment. A second visit for a minimum of one (1) day, travel time excluded, shall be provided for training and reviewing the Operations Manual. A third visit shall be made by the Manufacturer's factory personnel prior to the expiration of the system warranty. Additional field services shall be provided at a reasonable fee or at no charge, depending on the circumstances of the visit. Manufacturer's representative must have a fully equipped service facility with qualified technicians certified to service the equipment.

1.03 SUBMITTALS

- A. Shop Drawings: Shop drawings shall be submitted to the Engineer for the screen and its associated components. Scaled dimension drawings, layout drawings, anchor and installation details, and details of major components shall be included. Electrical and utility requirements shall be described.
- B. Product Data: Manufacturer's technical data and installation instructions shall be submitted along with pertinent data to substantiate material compliance with project requirements.
- C. Operation and Maintenance Manuals: One (1) copy of installation and operational manuals complete with operation and maintenance instructions shall be submitted including an arrangement drawing for layout and installation.
- D. Video: A detailed video specific to this Project shall be provided prior to delivery of the equipment. The video shall show the specific equipment for the project immediately following the quality control testing. The video shall be presented by a trained factory service engineer who shall go over in detail all aspects of operation and maintenance of the screen, compactor, controls, level sensing and other equipment associated with the project. The video shall show the equipment in operation and shall also cover equipment installation, spare parts and show equipment packed, crated and ready for shipment. The video shall be provided on a USB flash

drive and on a private web link. The purpose of the video is to assist with installation, operation and maintenance for the life of the equipment and provide operators with a permanent easy-to-follow and thorough guide to their equipment. As a result, generic operation or maintenance videos are unacceptable, the video must be specific to this particular application.

1.04 WARRANTY

- A. 12 months after start up or 18 months after delivery, whichever comes first.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable Manufacturers:
 - 1. Or-Tec, Inc.
 - 2. Headworks, Inc.
- B. Being named an “Acceptable Manufacturer” does not relieve said manufacturer from meeting all requirements in this specification.

2.02 GENERAL DESCRIPTION

- A. The Micro Bar Screen shall consist of a tapered bar screen panel, two (2) side frames, two (2) chains with multiple, penetrating, cushion mounted rakes, a drive motor, a compactor washer and a control panel.
- B. Equipment shall be installed so as not to obstruct the flow of sewage to bar screen. Screen components including shapes (rods, angles, and channels) pipes, sheets, side frames and guides, bar rack, rake assembly, scraper assembly, shafting, discharge chute, fasteners and anchor bolts shall be manufactured from Type 304 stainless steel. Mechanical Screens with any of these items manufactured from materials other than Type 304 stainless steel shall not be acceptable.
- C. The screen shall be designed and provided with support assemblies that allow it to pivot out of the channel as required for maintenance. When pivoted all screen components shall be above the top of the channel. The compactor shall be moved to allow the screen to pivot.

2.03 COMPONENTS

- A. Tapered-Bar Screen Panel
 - 1. Screen panel face shall consist of a parallel array of tapered bars with even spaces between them. This opening shall be 6 millimeters. Screens with larger openings between the bars allow more non-organic material, such as wipes, hair, plastics or other stringy material, to enter the plant and therefore shall not be acceptable. The lower end of each bar shall have a notch at the bottom side, and the bars shall be clamped at the notch points by a lower spacer beam. The upper end of each bar shall be curved downwards so that it passes through the screenings lead plate and is inserted into the sectional bar holes of the upper spacer beam which is located at the bottom side of the screenings lead plate. The screens tapered bars

shall extend one (1) foot above the highest possible water level in the channel. Tapered bars are used rather than flat bar stock as tapered bars only have one pinch point making it easier to clean the gap between the bars. Screens which use flat bar for the screen array have a continual pinch point between them making the gap between them difficult to clean. For this reason, use of flat bar stock in place of tapered bars shall not be acceptable.

2. The mid-section of the bar is cross-supported by v-notched support beams at every 12-inch to 20-inch interval. Screen bars shall be readily replaceable individually from the front of the screen without the need to remove the screen from the wastewater channel. Screens with screen bars that are not individually replaceable from the front of the screen shall not be acceptable.
3. All material for tapered bars, lower spacer beam, upper spacer beam, screenings lead plate and the support beams shall be made of 304 stainless steel. This tapered bar screen panel shall be mounted and bolted between a pair of side frames. Screens which utilize material other than stainless steel as the main screen media shall not be acceptable.
4. The screen shall be a self-cleaning system using only the penetrating rake teeth to fully clean the gaps between the tapered bars and keep the screen operational. No washwater shall be required by the screen for any purpose. No brushes, rotating or otherwise, shall be required by the screen for any purpose. Screens that utilize brushes or require washwater shall not be acceptable. Screens that use perforated flat panels in place of a bar screen shall not be acceptable.

B. Side Frames

1. A pair of side frames shall support the tapered bar screen panel between them. Bearings for head sprockets and bushings for tail sprockets with head shaft and tail shafts shall be mounted on them. Frames shall be made of Type 304 stainless steel plate of sufficient thickness to prevent deflection.
2. Guide rails shall be attached at the inside of the frames to ensure the systems chains and rakes run true. The guide rails shall be made of UHMW. Guide rails made of any material other than UHMW shall not be acceptable for this project as UHMW guide rails reduce the friction between the chain rollers and guide rails by 85% over standard stainless steel guide rails.

C. Chains, Rakes and Sprockets

1. Rakes shall travel up the screen face cleaning the screen opening with their penetrating teeth cleaning between the tapered bars while lifting the captured solids up to the top of the machine. The rakes shall be mounted on the chains on both sides of the side frames using cushion mounted brackets. The cushion mounted brackets shall enable the rakes to rotate 60 to 90 degrees backwards should any large foreign object be present or blockage occur, and then return to their position between the tapered bars. The cushion mounted bracket protects the mechanical parts of the rakes and pressure caused by the repeat action of the spring-loaded rake ensures any potential blockages are quickly removed. Systems with rakes or mechanical screen cleaning apparatus that do not have the ability to rotate shall not be acceptable.
2. The rakes shall travel at approximately 12 to 15 feet per minute. The rakes shall be mounted on the chain at no more than 48-inch intervals

3. Rake assembly shall be guided over the discharge chute and the accumulated debris shall be removed by a scraper attached to the side frames. Scraper shall be designed to pivot to achieve effective cleaning of bar screen openings with the rake. Rake scraper shall be made of Type 304 stainless steel.
4. Discharge material from screen shall be directed to a tapered chute providing a smooth transition from bar screen discharge to the screw compactor. Chute shall have a minimum slope of 55 degrees. Discharge chute shall be made of Type 304 stainless steel.
5. Screen chain head shaft sprockets and idling tail sprockets provided shall be manufactured of Type 304 stainless steel. Sprockets manufactured from materials other than Type 304 stainless steel shall not be acceptable. Sprockets shall be fitted to head shaft using precisely cut keyways.
6. Shafts provided shall be Type 304 stainless steel, straight and true, sized to transmit required power to the head sprockets.
7. Head shaft shall be equipped with heavy duty, grease-lubricated, adjustable, take-up bearing assemblies.
8. Tail shaft shall be equipped with heavy duty, lubrication-free, maintenance-free, sealed graphite immersed phenolic resin bushings. Screens with underwater bearings that require lubrication shall not be acceptable. Tail shaft bushing shall have a five (5) year warranty.
9. The self-tensioning apparatus of the rake chains makes the static tension of the chain zero. By causing the chain to operate at zero tension, wear and tear on the chain is decreased. Designs which cause chains to operate above zero tension shall not be acceptable for this project. The chain shall be made of Type 304 stainless steel.
10. Screen shall be capable of operating based on level sensor or I/O. Screen shall also be capable of operating continuously (24 hours a day, 7 days a week) when there is a continuous flow present if required. Screens which cannot operate according to all these parameters shall not be acceptable.
11. Screen shall be manufactured in an ISO 9001 and ISO 14001 certified facility.

D. Drive Motor

1. Equipment shall be provided complete with drive motors of totally enclosed geared induction type. A torque limiter combined with limit switch shall be provided between the motor and the head shaft in order to disconnect mechanical power in emergency situations.
2. System shall use a 1/2 HP, 3 phase, 230/460 Volt, 60 Hz motor. Systems which require larger motors shall not be acceptable for this Project.

E. Compactor Washer

1. The compact washer collects the screenings discharge from the screen and washes and compacts screenings. Filtrate from the compactor is directed back to the wastewater treatment plant.
2. Compactor Criteria
 - a. Model Number: SCR25120
 - b. Type: Dewatering Screw Press

- c. Inlet: From Screen
 - d. Drain Pan: With wash station
 - e. Quantity: One (1) set
 - f. Operation: Automatic based on timer in control panel
 - g. Motor Rating:.....2 HP, 3 phase, 230/460 Volt, 60 Hz
 - h. Discharge Height: Swan neck discharge tube, 4'-1" above grade
 - i. Materials: Frame, strainer, supports Type 304 stainless steel
 - j. Screw.....8-inch diameter epoxy coated carbon steel
3. The Screw compactor shall consist of an inlet hopper, a perforated trough, a screw auger, a washwater system, tapered discharge and a gear drive. Screenings are discharged into the unit hopper and are fed into the tapered discharge by the rotating screw auger. Through the squeezing action of the unit liquid is removed from the screenings and flows through the perforated section of the trough. The dewatered screenings are pushed out to the end of the "swan neck" discharge tube.
 4. Screw auger shall consist of a rotating shaft and spiral screw designed to push the screenings into the tapered discharge while rotating. The screw diameter shall be 8 inches and shall be manufactured from epoxy coated, hardened alloy carbon steel. The spiral screw shall be 1/2-inch thick with an 8-inch pitch and shall be manufactured from epoxy coated alloy steel.
 5. The compactor washer inlet hopper shall be manufactured from Type 304 stainless steel and shall be bolted to the casing of the screw compactor. The inlet hopper shall be designed to direct the screenings to the screw rotor of the unit. The discharge chute of the micro bar screen and compactor inlet hopper shall be designed to fit and seal together.
 6. The trough bottom shall have perforated openings. Screenings discharged into the hopper are fed into the tapered discharge by the rotating screw auger and squeezed. The discharged liquid flows through the tapered wire while the screenings are compacted. The compacting action is created by the action of the screenings in the strainer and "swan neck" discharge tube.
 7. A shower spray header for cleaning the slots of the strainer tube is attached over the strainer tube. Inlet nozzles of 3/4-inch diameter are fitted with a Type 304 stainless steel manual valve and a solenoid valve. Shower spray nozzle and solenoid valve shall be provided for the compactor and sealed filtrate catchment tray.
 8. A self-aligning thrust bearing shall manage the load created during compaction and shall allow the screw to reverse its rotation. The bearing shall fully support the screw so that the screw does not rest inside the press housing.
 9. A nylon brush shall be attached to the screw in the drainage area to prevent debris from lining the drain.
 10. Two (2) solenoid valves shall be fitted to the washwater inlet.
 11. System shall use a 2 HP, 3 phase, 230/460 Volt, 60 Hz motor. Systems which require larger motors shall not be acceptable for this project.
 12. Compactor washer shall be manufactured in an ISO 9001 and ISO 14001 certified facility

F. Odor Control

1. Connection point between the discharge of the screen and inlet of the Compactor washer shall be fully enclosed to reduce odors and to completely contain screenings. The discharge chute of Screen and Compactor inlet hopper shall be designed to fit and seal together. In order to ensure complete containment and control odors the screen and compactor washer shall be manufactured by the same company. Screens and compactor washers not manufactured by the same company shall not be acceptable for this reason.

G. Level Sensor

1. An ultrasonic level sensor shall be provided to be mounted in the channel upstream of the screen to detect water level in the channel. A controller for this unit shall be provided in the system control panel. The controller shall allow easy control of the level sensor with set points for on/off and high-level alarms. Unit shall have two (2) independently settable C-form output contacts, shall be housed in a NEMA 6 polycarbonate enclosure, and shall be CSA rated for a Class I, Division 2, Group C and D hazardous environment. The sensor shall be mounted above the channel by means of Type 304 stainless steel bracket and shall have two (2) 1/2-inch NPT conduit connections.

H. Control Panel

1. The one (1) control panel shall be a NEMA 4X enclosures suitable for outdoor use and shall contain all electrical controls, wires, starters, terminals, relays, overloads, fuses and labels required for operation of the screen and ancillary equipment described herein.
2. The system shall be fully operational in both manual and automatic modes. The system mode selector switch shall allow the operator to select the desired mode. No other changes or programming by the operator shall be required. System shall be controlled by a PLC.
3. In manual mode the screen shall start and operate until it is turned off. In automatic mode the system shall turn on based on a signal from the level sensor provided or operate continuously if there is continuous flow to the screen. When using level sensors or I/O the screen shall operate for one (1) minute based on the signal. If at the end of one (1) minute the signal from the level sensor is still made the screen shall operate for one (1) more minute. When the level sensor is no longer made the screen shall turn off and wait for the next signal.
4. PLC in the panel shall allow the operator to easily change the on/off period of the compactor washer wash systems.
5. The front of the control panel door shall include a main disconnect breaker switch (power on/off). In the off position all power to the control panel shall be off. An electronic current overload relay shall continuously monitor the screen motor and shall alarm the panel in the event of an over current draw.
6. The control panel shall contain the following. All switches and switching functions shall be clearly indicated by suitably engraved labels.
 - a. Main disconnect, "thru the door" with door interlock
 - b. Full voltage non reversing motor starter (IEC) with bimetallic overload relay with thermal trip Class 10 overload protection and Low-Peak time delay Class CC fusing
 - c. Control transformer 500va, with primary and secondary fusing

- d. Control power on/reset illuminated push button
- e. HOA Switching and run/alarm lights
- f. PLC controller for manual and automatic operation
- g. Elapsed time meter
- h. Lot, control relays, terminal blocks and related accessories.
- i. UL listing

PART 3 EXECUTION

3.01 INSTALLATION

- A. General: Install screen and associated components as shown on the plans and in accordance with Manufacturer's instructions.

3.02 TESTING AND INSPECTION

- A. General: Notify Owner and Engineer in writing when the installation is complete and ready for testing and start up.
- B. Inspect components for proper installation, wiring and piping.
- C. Operate all components and check for proper operation. Make necessary adjustments.

END OF SECTION

SECTION 46 30 00

WATER & WASTEWATER CHEMICAL FEED EQUIPMENT

PART 1 GENERAL

1.01 Scope

A. The work under this section includes the furnishing of all labor, materials, equipment, documentation, testing, training, and startup services for the manufacture and installation of skid mounted chemical metering systems suitable for the Cleveland WWTP Upgrades project, to feed alum and sodium hydroxide at the rates and pressures specified in this section.

1.02 Work Specified Herein

A. Equipment

- Chemical Metering Pumps and Pump Controls
- Chemical Metering Skids and Accessories
- Chemical storage tanks with secondary containment
- Instrumentation, controls, and SCADA equipment
- Spare Parts as recommended by manufacturer

B. Execution

- Testing
- Installation
- Commissioning and performance testing
- Training and startup services

1.03 Quality Assurance

A. Acceptable Manufacturers

- a. Equipment of this section shall be provided by a single manufacturer, who shall demonstrate previous experience in the design and fabrication of skid-mounted chemical metering systems, shall provide the products of this section. The

qualified manufactures are listed as such: Watson-Marlow peristaltic pumps mounted on Tech Equipment pump skids.

- b. Blue-White CFPS M3/M4 series pumps and engineered skid systems.
 - c. Eco-Tech Qdos diaphragm pumps and skids.
 - d. Engineer-approved equal.
- Pumps to be manufacturer's standard product. Manufacturer of tubing pumps must have at least 20 operating installations in domestic water or wastewater treatment plants located in the United States over a period of at least seven years pumping the same fluid as specified
 - The metering skids shall be a regularly marketed product of the manufacturer who must have a physical plant, technical and design staff, and production personnel located in the USA to complete the work as specified. Systems assembled by second party fabricators, integrators, contractors or manufacturers not normally engaged in chemical metering system design and manufacturing shall not be acceptable.
 - The manufacturer shall supply a minimum of five separate references with contact names and phone numbers, where substantially similar installations for the equipment as specified has been in satisfactory operation for a minimum of two years.
 - The manufacturer shall have a minimum of 5 years' experience with a successful record of manufacturing and servicing of systems as specified herein.
 - The manufacturer shall have a proven track record of after-market sales and service support on its equipment.
 - The products of this section shall be manufactured by Tech Equipment or engineer approved equal.

1.04 WARRANTY

- A. The system manufacturer shall provide a three (3) year warranty for the metering pumps (1-year for liquid end), skid material/construction, and skid-mounted equipment, piping and valves. This warranty shall be in addition to and not in lieu of any warranties provided by the manufacturer of the equipment itself.

1.05 SECTION SPECIFIC SUBMITTALS

- A. The information requested in this section is required in order to determine that the manufacturer has the ability and resources to provide equipment that meets the design, fabrication and quality standards as set forth herein. Any submittals that do not include this information shall be returned as "Rejected".
- B. In addition to the general submittals as specified herein and elsewhere, the following CAD drawings shall be provided as a part of the submittal package in a section labeled SHOP DRAWINGS for each chemical metering system included in this section. The drawings shall be

produced for the specific equipment to be provided for this project. Marked up copies of general product information is not acceptable.

- C. Detail Layout Drawing – The detail drawings shall include the following:
- D. Top, front, side and isometric views for the proposed metering systems.
- E. Top, front and side views shall include accurate overall dimensions and location and dimensions for all piping connections.
- F. Isometric view shall include callouts indicating all skid mounted components and piping connections.
- G. A table shall be provided with the quantity, part number, description, P/M kit and recommended maintenance interval for all major equipment items and metering accessories.

1.06 SERVICE CONDITIONS

- A. This project includes chemical metering systems designed for pumping alum and sodium hydroxide. All components shall be resistant to corrosion from contact with these chemicals.

PART 2 Equipment

2.01 General

- A. The chemical metering systems shall be completely self-contained and designed to safely feed metered amounts of all chemicals as listed under Service Conditions. Each chemical metering skid shall include chemical metering pumps, accessories, controls and options as indicated in this specification and the contract drawings.

2.02 Acceptable Manufacturers:

- A. A. The Manufacturer shall be a company specializing in manufacture, assembly, and field performance of peristaltic metering pumps with a minimum of five years of experience.
- B. B. The Qdos series metering pumps shall be manufactured by Watson Marlow or engineer approved equal as listed above.
- C. C. The metering pump skid shall be manufactured by Tech Equipment or engineer approved equal as listed above.

2.03 Chemical Metering Pump

- A. Pump Process Schedule

Quantity	1 Alum Unit (2 pumps per skid, duty + standby)	1 NaOH Unit (2 pumps per skid, duty + standby)

Tag Number(s)		
Fluid	12% alum solution	50% NaOH solution
Min– Max Capacity (GPH)	1.1 – 4.55	2.2 – 8.8
Typical operating condition (GPH)	2.3	4.4
Operating discharge pressure (PSI)	As required by manufacturer	As required by manufacturer
Suction Head	As required by manufacturer	As required by manufacturer

B. Pump Construction

1. Pumphead

- a. Technology: Provide tool-free ReNu cartridge-style peristaltic pumphead technology.
- b. For operator safety, pumphead must be serviceable as a single replaceable component. Pumps that require an operator to open the pumphead for tube replacement, cleaning, or rebuilding or that require tools for maintenance are unacceptable.
- c. Max rating: Manufacturer recommendation psi of discharge pressure.
- d. Max Suction Rating: Self priming with a maximum suction lift capability of 30 feet vertical water column
- e. Housing construction: corrosion resistant and high impact resistant glass filled PPS or PPE/PS.
- f. Geometry: Pumphead shall consist of sealed track housing with in-line porting.
- g. Suction and discharge ports shall be 180 degrees apart with bottom suction and top discharge.
- h. Rotor: Pumphead rotor shall be constructed of glass filled Nylon, sealed within the track housing, and supported by its own bearings. Peristaltic occlusion level shall be factory set to ensure flow accuracy of +/- 1% and repeatability performance of +/- 0.5% and shall not require any field adjustment.
- i. Contact Materials: All pumphead components in the fluid path must be NSF61 listed and shall be of materials specified by the manufacturer as compatible with the process fluid.
- j. Leak containment/detection: In the event of peristaltic element failure, the leak sensor shall shut the pump down immediately with all process fluid contained within the sealed pumphead.
 - 1) Sensor type: Utilize non-contacting optical sensor. Sensor shall not come in contact with the process fluid, shall contain no moving parts, shall not depend on the capacitance of the process fluid, shall not require fluid to leak out of the pump housing for engagement, nor shall require any sensitivity or calibration adjustment.
 - 2) Alarm: Sensor shall shut down the pump, give a visual indication on the drive controller, and if specified shall provide an output general alarm signal.

- 3) For operator and environmental safety, pumps which do not have leak containment, leak sensor, and shutdown are not acceptable. For additional overpressure safety, sealed pumphead shall have a controlled drain-to-waste port.
 - k. Port connections: Pumphead shall utilize polypropylene compression fittings which shall mate to 10mm ID reinforced, transparent PVC interface hose.
2. Drive
- a. Rating: Continuous 24 hour operation, 45o C ambient.
 - b. Voltage: Drive shall be suitable for 100-240VAC, 50-60Hz, 1-Phase with an internal switch-mode power supply. Supply nine-foot length mains power cord with standard 115VAC three-prong plug.
 - c. Max drive power consumption: 190VA.
 - d. Enclosure: NEMA 4X constructed out of corrosion and impact resistant engineering plastic, 20% Glass filled PPE/PS. By nature of the environmental conditions, painted or unpainted metallic housing including 316SS are not acceptable. Enclosure shall house the drive motor and all control circuitry in one integrated unit. Separate VFDs and motors are not acceptable.
 - e. Direct coupled pumphead with fully protected drive
 - 1) Pumphead shall direct couple mount to the controller via a splined driveshaft and shall be locked in place by two tool-free thumbscrews or lever mechanism.
 - 2) Pumphead shall be fully sealed to prevent any contamination of the controller or drive shaft by process fluid.
 - 3) Pumphead shall contain its own rotor bearings and not impart an overhung load on its pump shaft
 - 4) Pumpheads shall be supplied mounted to the left or right side of the drive enclosure as specified in the drawings. If not specified, pumpheads shall mount to right side of the enclosure.
 - 5) Drive shall stop rotation and give visual alarm in the event the pumphead is removed
 - f. Drive motor: brushless DC motor with integral gearbox and closed loop tachometer feedback.
 - g. Circuitry complete with temperature and load compensation protection

2.04 Chemical Metering Pump Controls

A. Manual Control Interface

Pumps must meet the following minimum requirements for human-machine interface (HMI) manual operator functionality. Pumps not meeting this minimum functionality will not be accepted

1. Display: Backlit graphical TFT Display capable of up to 8 lines of text with up to 26 characters per line to display pump tag number, flow rate, and programming instructions. Display shall also provide visual indication of running status via screen color: Blue = Running, White = Stopped and Red = Warning.

2. Keypad: Keypad for start, stop, speed increment, speed decrement, rapid prime, and programming.
3. Flow units: Programmable in either ml/min or gallons/hour.
4. Security: Programmable keypad lock and PIN security for optional lockout of all keys except emergency start/stop.
5. Auto Restart: feature to resume pump status in the event of power outage interruption.
6. Multilingual menu: include programming menus in nine languages, including at a minimum English, Spanish, and French.
7. Fluid level monitor: Programmable flow totalization to advise operator when their supply tank is low.

B. Remote Control I/O

Supply auto control features to meet the minimum functionality requirements for the use with Scada System. Pumps not meeting this minimum functionality will not be accepted

1. Speed Control Input: Analog 4-20mA speed input with 1,600:1 turndown with incremental steps of 10 microamps.
 - a. *****If scalable and programmable response to speed signal is required, alternatively specify the following: a Speed Control Input: Analog 4-20mA speed input with 1,600:1 turndown with incremental steps of 10 microamps. Signal must be trimmable and speed scaleable over any part of the drive speed range. Pump shall be programmable to either increase pump speed or decrease pump speed against an increasing Analog 4-20 mA signal. *****
 - b. Run/Stop Input: Either 5-24V industrial logic, dry contact or powered 110 VAC contacts as shown per the process and instrumentation drawings.
 - c. Run/ Stop & General Alarm status Outputs: Either 24VDC Open Collector, 24 VDC Status relay, or 110V AC Status Relay
 - d. *****If alternative status outputs are required, specify the following:
 - 1) Status Outputs: Two status outputs 24VDC Open Collector, 24VDC Status relay, or 110VAC Status Relay as required by the process and instrumentation drawings software configurable to indicate the following:
 - 2) General Alarm status
 - 3) Running/Stopped status
 - 4) Manual Mode status
 - 5) Analog Mode status
 - 6) Contact Mode status
 - 7) Fluid Level status
 - 8) Leak Detected status*****
 - e. *****If a speed feedback signal is required, specify the following:
 - 1) Speed Analog Output: Analog 4-20mA *****

END OF SECTION

SECTION 46 33 44
PERISTALTIC METERING PUMPS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes: Skid-mounted chemical feed system completely assembled, mounted, calibrated, wet tested, pressure tested at the Manufacturer's facility and delivered to the site ready to connect. The skids shall include the metering pumps, calibration column, piping, valves, unions, pulsation dampener, back pressure valve, pressure relief valve, pressure gauge and flow indicator.

1.02 RELATED WORK

- A. Section 09 90 00 Painting
- B. Section 40 05 07 Hangers and Supports for Process Piping
- C. Section 40 05 14 PVC Pressure Pipe
- D. Section 40 05 52 Valves
- E. Electrical work, except as specified herein, is included in Division 26

1.03 SUBMITTALS

- A. Requirements for Submittals: See Section 01 33 00 Submittal Procedures.
- B. Product Data: Submit to the Engineer Manufacturer's catalog data, including system materials and all associated components/equipment.
- C. Submittals shall include at least the following.
 - 1. Manufacturer's certified rating data
 - 2. Complete description of all materials
 - 3. Certified shop and installation drawings including piping schematics, details of construction, dimensions, and anchor bolt locations
 - 4. Descriptive literature, bulletins, and/or catalogs of the equipment
 - 5. The total operational weight of the equipment including the weight of the single largest component
 - 6. Complete bill of materials of all equipment
 - 7. Description of the factory finish and/or surface preparation and shop priming of equipment
 - 8. A list of the Manufacturer's recommended spare parts
 - 9. Complete motor data
 - 10. Data demonstrating compatibility of pump materials of construction with chemical service

- D. Submit operation and maintenance manuals in accordance with Section 01 70 00 Execution and Closeout Requirements of these Specifications

1.04 REFERENCE STANDARDS

- A. Design, manufacturing and assembly of elements of the products specified herein shall be in accordance with the standards of the below listed organizations.
 - 1. American Society for Testing and Materials (ASTM)
 - 2. American National Standards Institute (ANSI)
 - 3. National Electrical Manufacturers Association (NEMA)
- B. Where reference is made to a standard of one of the above, or other organizations, the version of the standard in effect at the time of Bid Opening shall apply.

1.05 QUALITY ASSURANCE

- A. All equipment furnished as specified within this Specification shall be new and unused.
- B. All equipment as specified within this Specification shall be standard products from Manufacturers who have a successful record of manufacturing and servicing the equipment and systems specified herein for a minimum of five (5) years. The equipment shall be designed, constructed and installed in accordance with best practices and methods, and shall operate satisfactorily when installed.
- C. These Specifications are intended to give a general description of what is required, but do not cover all details which may vary in accordance with the exact requirements of the equipment as offered. These Specifications are intended to cover the furnishing, delivery, installation, field testing and field calibration of all materials and apparatus as required. Any additional equipment necessary for the proper operation of the proposed installation not specifically mentioned in these Specifications or shown on the Contract Drawings shall be furnished and installed at no change in Contract Price or Time.

1.06 DELIVERY STORAGE AND HANDLING

- A. Provide in accordance with Section 01 60 00 Product Requirements.
- B. All equipment and parts shall be properly protected so that no damage or deterioration occurs during shipment or during a prolonged delay from the time of shipment until installation is completed and the unit and equipment are ready for operation. The Contractor shall store equipment in accordance with the Manufacturer's instructions.

1.07 WARRANTY

- A. The Contractor and the Manufacturer shall warrant all equipment supplied under this Specification for a period of one (1) year. Warranty period shall commence as outlined in Division 01 General Requirements of these specifications.

- B. The equipment shall be warranted to be free from defects in workmanship, design and materials. If any part of the equipment should fail during the warranty period, it shall be replaced in the machine(s) and the unit(s) restored to service at no expense to the Owner.
- C. The Manufacturer's warranty period shall run concurrently with the Contractor's warranty period. No exception to this provision shall be allowed.
- D. Refer to the Division 01 General Requirements of these Specifications for additional warranty requirements.

1.08 MANUFACTURERS

A. Approved Manufacturers for peristaltic chemical metering pumps include:

- 1. Blue-White Industries
- 2. Watson-Marlow

PART 2 – PRODUCTS

2.1 SKID SYSTEM

A. Design Criteria

- 1. Single pump systems and dual pump systems shall be constructed using a polyethylene structure. The skid shall permit the installation of any Blue-White Industries Chem-Pro series diaphragm metering pumps or Flex-Pro Proseries-M peristaltic metering pumps.
- 2. There shall be two (2) side walls for support and a pump mounting base.
- 3. There shall be a chemical spill containment area located at the base of the frame.
- 4. There shall be a drain port to drain fluid from containment area.
- 5. Four (4) Type 316 stainless steel skid mounting pads shall be provided which can be positioned to enable either floor mounting or wall mounting the skid. Each mounting pad shall be secured to two (2) mounting holes in the skid structure by 18-8 stainless steel hardware.
- 6. Two (2) Type 316 stainless steel pump mounting brackets with four (4) mounting slots shall be provided. Pump mounting brackets shall be secured to a HDPE plate. The HDPE plate shall be mounted to the skid structure by 18-8 stainless steel hardware.
- 7. Custom engineered universal mounting brackets shall secure each of the ball valves to the skid structure. Valve mounting brackets shall be PA12. Valve mounting brackets shall be secured by threaded inserts in the skid structure by 18-8 stainless steel hardware.
- 8. Single skid piping shall be 1/2 inch diameter Schedule 80 PVC or CPVC. Dual skid piping shall be 1-1/2 inch diameter PVC or CPVC on the inlet side and 1/2 inch PVC or CPVC on the outlet side.
- 9. Vented ball valves shall be PVC or CPVC with PTFE shaft bearings and seals.
- 10. Unions shall be Schedule 80 PVC or CPVC.
- 11. Seals may be specified as either FKM or EPDM.
- 12. Two (2) chemical inlet ports shall be provided.

13. System shall have a two (2) year Manufacturer's warranty.

B. Flow Indicator

1. Shall be in the discharge side of the piping system to provide a visual indication of fluid movement through the system.
2. The flow indicator body shall be machined from clear cast acrylic with a ceramic ball indicator and PVDF ball stop.
3. The flow indicator shall be secured to the piping system with PVC or CPVC connectors and polypropylene half unions.

C. Check Valve

1. Shall be located on the discharge side of the piping system at the pump injection point to prevent the back flow of fluid through the system.
2. The check valve shall be PVC with a 1.0 to 1.5 psi cracking pressure and manufactured by Plast-O-Matic.
3. The maximum inlet working pressure shall be 150 psi.

D. Pressure Relief Valve

1. Shall be located in the discharge side of the piping system to prevent excessive pressure in the system. Fluid shall be returned to the inlet side of the system if the pre-set maximum system pressure is exceeded.
2. The valve shall be PVC with a PTFE diaphragm seal manufactured by Griffco Valve, Inc.
3. The pressure adjustment screw and lock nut shall be polypropylene.
4. Infinite adjustment increments from 10 to 150 psi shall be possible.
5. An outlet safety vent port shall be provided with 1/8 inch F/NPT connection.

E. Pump Connections

1. Shall be flexible, reinforced braided PVC tubing rated for 200 psi maximum continuous duty and terminated to half unions with stainless steel hose clamps. The tubing shall be NSF listed.
2. Single pump systems shall include two (2) chemical injection inlet ports; one (1) for the primary chemical injection and one (1) for use as a secondary chemical inlet port or as a flushing port.

F. Inlet Strainer (optional)

1. Shall be in the suction side of the piping system.
2. The Y-type dampener shall be PVC with removable screen (1/32-inch mesh) manufactured by Hayward Flow Control Systems.

G. Calibration Cylinder (optional)

1. Shall be in the inlet side of the system to permit metering pump output volume calibration.
2. Valves shall permit the cylinder to be filled by gravity or by by-passing the chemical metering pump output into the cylinder.

3. The PVC cylinder shall be manufactured by Griffco Valve, Inc. with PVC end caps.
4. An outlet vent shall be provided with 1/4-inch inner diameter tubing barb connection.
5. Available sizes:
 - a. 1.6 GPH (100 mL), 4 GPH (250 mL), 8 GPH (500 mL), 16 GPH (1,000 mL), 32 GPH (2,000 mL), 64 GPH (4,000 mL)

H. Pulsation Dampener (optional)

1. Shall be in the discharge side of the system to reduce pulsation.
2. A ball valve shall be provided to permit the dampener to be removed for service.
3. The dampener shall be CPVC with 10 cubic inches of volume manufactured by Blacoh.

I. Pressure Gauge with Guard (optional)

1. Shall be in the discharge side of the system to indicate system pressure.
2. The liquid-filled gauge shall be stainless steel and include a blow-out plug manufactured by McDaniel.
3. The gauge shall be bottom-mounted to the guard with 1/4 inch NPT stainless steel threads.
4. The temperature compensated oil-filled gauge guard shall be PVC.
5. Available sizes:
 - a. 0-30 psi, 0-100 psi, 0-200 psi

J. Flow Meter (optional)

1. Shall output high-speed digital pulse signal or 4-20 mA, while pump is running only, to verify chemical injection.
2. Flow meter shall be of ultrasonic transit time technology.
3. Wetted components shall be PVDF, PVC (optional CPVC), PEEK, and TFE/P (optional EP).
4. End fittings shall be PVDF with optional PVC or CPVC slip fittings. All are included.
5. Flow meter operating range shall be as follows: (*Engineer to specify*)

<u>Code</u>	<u>Flow Range (GPH)</u>	<u>Flow Range (LPH)</u>	<u>Flow Range (mL/min)</u>
A	0.158-79.2	0.597-299.4	10.0-5,000
B	1.580-158.5	5.970-600.0	100-10,000

6. Shall provide a scalable 4-20 mA sourcing output.
7. Shall provide a scalable 0 to 10,000 Hz open collector frequency output
8. Shall provide a programmable Form C Solid State Relay rated for a maximum load capacity of 24 VDC and 100 mA.
 - a. Programmable for high/low flow rate alarm.
 - b. Programmable to energize on specified flow total.
9. Power Requirements: 5 VDC; 5 Watts maximum.

10. Shall be certified to NSF Standard 61 Drinking Water System Components.
11. Accuracy shall be +/-0.75% full scale. Accuracy shall be +/-0.25% at the field-calibrated setpoint.
12. Display
 - a. Shall provide the flow rate, flow total readout, chemical profile, and meter status.
 - b. Shall be programmable in volume units of milliliters, liters, or gallons and time units of minutes, hours, or days.
 - c. Rated NEMA 4X (IP66) for both integral and remote display.
 - d. Integral display shall be of LED type and display meter condition.

K. Manufacturer

1. The skid system shall be ProSeries, Chem-Feed[®] model CFPS manufactured in the United States by Blue-White Industries.

2.2 METERING PUMP

A. Design Criteria

1. Pumps shall be positive displacement peristaltic type with a brushless variable speed motor, non-spring-loaded roller assembly located in the pump head, integral tube failure detection system, tube life roller revolution counter with user alarm set-point, and flexible tubing with attached connection fittings. Flex-Pro M-3 model shall be capable of output volumes from 0.0002 to 33.3 gallons per hour. Flex-Pro M-4 model shall be capable of output volumes from 0.002 to 158.5 gallons per hour.
2. Pumps shall be capable of 24-hour continuous duty, self-priming, and operating in either direction of flow at the maximum rated pump pressure of up to 125 psi (8.6 bar).
3. Pumps shall be capable of running dry without damaging effects to pump or tube.
4. Pump shall use no check valves or diaphragms and shall require no dynamic seals in contact with pumpage. Process fluid shall be contained within pump tubing and shall not directly contact any rotary or metallic components.
5. Flow shall be in the direction of the rotor rotation, which can be reversed and shall be proportional to rotor speed.
6. Pump shall have a maximum suction lift capability of up to 30 feet vertical water column.
7. Pump shall have a five (5) year Manufacturer's warranty that includes chemical damage to the pump head and roller assembly for a period of two (2) years.

B. Pump Head

1. Shall be a single, unbroken track with a clear removable cover.
2. Tube failure detection sensors shall be wholly located in the pump head. Tube failure detection system shall not trigger with water contact. Float switch type switches shall not be used. Process fluid waste ports or leak drains shall not be provided.
3. Squeeze rollers with encapsulated ball bearings shall be directly coupled to a one-piece thermoplastic rotor. Four (4) Kynar (PVDF) or Nylon rollers shall be provided; two (2) squeeze rollers for tubing compression shall be located 180 degrees apart and two (2) guide

rollers that do not compress the tubing shall be located 180 degrees apart. The roller diameters and occlusion gap shall be factory set to provide the optimum tubing compression; field adjustment shall not be required. Spring-loaded or hinged rollers shall not be used.

4. Rotor assembly shall be installed on a D-shaped, chrome plated motor shaft and removable without tools.
5. For tubing installation and removal, rotor assembly shall be rotated by the motor drive at 6 rpm maximum when the pump head cover is removed. Hand cranking of the rotor assembly shall not be required.
6. Pump head and tubing compression surface shall be corrosion resistant Valox thermoplastic.
7. The pump head cover shall be clear, annealed acrylic thermoplastic with an integral ball bearing fitted to support the overhung load on the motor shaft. Cover shall include an embedded magnetic safety interlock which shall limit the motor rotation speed to 6 rpm when removed.
8. Cover shall be positively secured to the pump head using a minimum of four (4) thumb screws. Tools shall not be required to remove the pump head cover.

C. Pump Tube Assembly

1. To ensure pump performance and accuracy, only tubing provided by the Manufacturer is acceptable.
2. Pump tube shall be assembled to connection fittings of PVDF material.
3. Connection fittings shall be permanently clamped to the tubing with stainless steel clamps. To prevent tubing misalignment and ensure accuracy, fittings shall insert into keyed slots located in the pump head and secured in place by the pump head cover.
4. Connection fittings shall be 1/2 inch M/NPT. (Engineer to specify)
Alternate:
 - a. Fittings shall accept 1/4 inch inner diameter x 3/8 inch outer diameter flexible tubing.
 - b. Fittings shall accept 1/2 inch inner diameter flexible tubing.
 - c. Fittings shall accept one-way check valve Quick Disconnect Adapters. Wetted components shall be PVDF, Viton (optional EPDM), and Hastelloy C spring.
 - d. Fittings shall accept 3/4 inch tri-clamp adapters.
5. Tube sizes and connections shall be measured in inches.

D. Drive System

1. Shall be factory installed and fully enclosed in a NEMA 4X, (IP66) wash-down enclosure. Capable of operating on any input power from 110 VAC to 240 VAC, 50/60 Hz single phase supply without user configuration or selection switches.
2. Motor
 - a. Reversible, brushless DC gear motor rated for continuous duty.
 - b. Motor shall include overload protection.
 - c. The maximum gear motor rpm shall be 125 rpm.

3. Enclosure

- a. Pressure cast aluminum with acidic liquid iron phosphate three-stage clean and coat pretreatment and exterior grade corrosion resistant polyester polyurethane powder coat.
- b. Rated NEMA 4X (IP66).
- c. Provided with Type 316 stainless steel floor/shelf level mounting brackets and hardware.
- d. A wiring compartment shall be provided for connection of input/output signal wires and alarm output loads to un-pluggable type terminal block connectors. Terminal board shall be positively secured to the rear of the pump housing by two (2) polymeric screws and fully enclosed by the wiring compartment cover. The terminal board shall not be disturbed by the removal of the wiring compartment cover. Ribbon cables shall not be used in the wiring compartment. Conduit hubs, liquid-tight connectors, connector through holes and tapped holes shall be sized in inches.

4. Control Circuitry

- a. All control circuitry shall be integral to the pump and capable of adjusting the pump motor speed from 0.001% to 100.0% in 0.001% increments less than 1% motor speed, in 0.01% increments between 1% and 10% motor speed, and in 0.1% increments greater than 10% motor speed (10,000:1 turndown ratio).
- b. The pump output shall be capable of being manually controlled via front panel user touchpad controls. The pump motor speed shall be adjustable from 0.001% to 100.0% in 0.001% increments less than 1% motor speed, in 0.01% increments between 1% and 10% motor speed, and in 0.1% increments greater than 10% motor speed.
- c. The pump output shall be capable of being remotely control via 4-20mA analog input. The input resolution shall be 0.01 of input value and capable of adjusting the pump motor speed from 0% to 100.0% motor speed in 0.1% increments. Four (4) values shall be user configurable to define the low and high points on the output slope; a low input value, the required pump percentage of motor speed at the low input value, a high input value, the required pump percentage of motor speed at the high input value.
- d. The pump output shall be capable of being remotely control via 0-10 VDC input. The input resolution shall be 0.01 of input value and capable of adjusting the pump motor speed from 0% to 100.0% motor speed in 0.1% increments. Four (4) values shall be user configurable to define the low and high points on the output slope; a low input value, the required pump percentage of motor speed at the low input value, a high input value, the required pump percentage of motor speed at the high input value.
- e. The pump output shall be capable of being remotely controlled via TTL/Cmos digital high speed pulse type input and an AC sine wave type pulse input in the range of 0 to 1000 Hz. The frequency resolution shall be 1 Hz and capable of adjusting the pump motor speed from 0% to 100.0% motor speed in 0.1% increments. Four (4) values shall be user configurable to define the low and high points on the output slope; a low input value, the required pump percentage of motor speed at the low input value, a high input value, the required pump percentage of motor speed at the high input value.
- f. The pump output shall be capable of being remotely control via pulse triggered batching. The pump shall accept a TTL/Cmos digital pulse type input and a contact closure type pulse input in the range of 1 to 9999 pulses per batch. The batch time shall

be adjustable from 1 to 999999.9 seconds. The pump motor speed during the batch shall be adjustable from 0% to 100.0% motor speed in 0.1% increments.

- g. The pump shall include an internal cycle timer capable of automatically cycling the pump on and off. The pumping total cycle time shall be adjustable from 1 to 999999.9 seconds. The pumping on time during the cycle shall be adjustable from 1 to 999999.9 seconds. The pump motor speed during the cycle shall be adjustable from 0% to 100.0% motor speed in 0.1% increments.
- h. The pump shall be capable of dispensing upon demand. The dispensing shall be manually triggered by pressing the front panel start button or by inputting a contact closure. The dispensing volume shall be adjustable from 1 to 999999.9 milliliters. The pump motor speed during the dispensing cycle shall be adjustable from 0% to 100.0% motor speed in 0.1% increments.
- i. The pump shall be capable of automatically calculating the pump motor speed required to achieve a part per million dosing output that is proportional to a fixed system flow rate. The pump shall permit the user to input the dispensing chemical percentage concentration from 0% to 100.0% in 0.1% increments. The pump shall permit the user to input the dispensing chemical specific gravity from 0.1 to 9.9 in 0.1 increments. The pump shall permit the user to input the fixed system flow rate from 1.0 to 9999.9 liters per minute in 0.1 liters per minute increments. The pump shall permit the user to input the required dosing parts per million (ppm) from 0.1 to 100.0 in 0.1 increments.
- j. The pump shall be capable of automatically calculating the pump motor speed required to achieve a part per million dosing output that is proportional to a variable system flow rate. The pump shall permit the user to input the dispensing chemical percentage concentration from 0% to 100.0% in 0.1% increments. The pump shall permit the user to input the dispensing chemical specific gravity from 0.1 to 9.9 in 0.1 increments. The pump shall permit the user to input a K-factor in pulses per liter from a sensor in the water system that outputs a high-speed digital pulse from 0 to 1000 Hz that is proportional to the system water flow velocity. The pump shall permit the user to input the required dosing parts per million (ppm) from 0.1 to 100.0 in 0.1 increments.
- k. Provide an 11-button front panel user touchpad control for stop/start, configuration menu access and navigation, operating mode selection, auto priming, display options selection, tube life data, and reverse direction.
- l. Provide a multi-color VGA graphic LCD display for menu driven configuration settings, pump output value, service alerts, tube failure detection (TFD) system and flow verification system (FVS) alarms status, remote input signal values, tubing life timer value. Display color shall be green to indicate normal operation, blue to indicate stand-by, and red to indicate an alarm condition exists.
- m. Provide for remote stop/start pump via 6-30 VDC powered loop or non-powered contact closure loop.
- n. Provide a user-selectable 4-20mA and 0 to 1000 Hz output signal which are scalable and proportional to pump output volume.
- o. Provide four (4) contact closure alarm outputs. Three (3) rated at 1A-115 VAC, 0.8A-30 VDC and one (1) rated at 6A-250 VAC, 5A-30 VDC. Each alarm output shall be assignable to monitor any of the following pump functions: TFD system, FVS system, motor run/stop, motor failed to respond to commands, motor is running in reverse, general alarm (TFD, FVS, and/or motor over current), input signal failure, output

signal failure, remote/local control status, revolution counter (tube life) set-point, or monitor which of the nine (9) different pump operating modes is currently active.

- p. Provide a four-digit password protected configuration menu.
- q. Provide a flow verification system (FVS) with programmable alarm delay time from 1 to 255 seconds. FVS system shall monitor the FVS flow sensor while pump is running only. System shall not monitor pump while not running.
- r. Provide a roller revolution counter display (tube life indicator) with user programmable alarm set-point value from 1 to 999,999,999 revolutions which can be assigned to any one of the four (4) contact closure alarm outputs.
- s. Provide a user-programmable maximum rpm (revolutions per minute) set-point value from 0.1 to 100.0 rpm in 0.1 increments.
- t. Provide a user adjustable response delay time from 0 to 999.9 seconds for the remote start/stop input and the four (4) contact closure alarm outputs to facilitate closed-loop applications.
- u. Provide a power interruption pump restart option which is user programmable to either automatically re-start or require a user re-start if AC mains power is interrupted.

E. Safety

- 1. The pump shall be certified to NSF Standard 61 Drinking Water System Components, UL Standard 778 Motor Operated Pump and CSA Standard C22.2 Process Control Equipment.
- 2. Manufactured to ISO 9001:2015 Quality Management System requirements.
- 3. Tube Failure Detection (TFD) system sensors shall be wholly located in the pump head. TFD system shall stop the pump within three (3) seconds of leak detection. To prevent false alarms due to rain, wash-down, condensation, etc., tube failure detection system shall not trigger with water contact. Process fluid waste ports or leak drains shall not be provided.
- 4. Pump head cover shall include an imbedded magnetic safety interlock which shall stop the pump when removed. Pump rotor speed shall be limited to 6 rpm when cover is removed.
- 5. Secondary user confirmation input required for motor reversal, tube life revolution count reset, and factory default configuration reset.

F. Manufacturer

- 1. The pump shall be Flex-Pro Proseries-M peristaltic pumps, manufactured in the United States. by Blue-White Industries.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Installation shall be in strict accordance with the Manufacturer's instructions and recommendations in the locations shown on the Contract Drawings.
- B. Contractor to supply hose barb-to-process line adapters for connection of pump tubing to process lines. Hose barbs to be secured to the pump tubing via a stainless steel clamp tightened around the outer diameter of the tubing.

- C. Contractor shall field mount equipment to the FRP pump tables using chemical compatible anchors.
- D. The equipment supplier shall provide two (2) days of field supervision to assist the Contractor with installation. The field inspection shall be performed by a factory service representative familiar with the product line.
- E. All electrical conduits shall be connected to the motors with flexible, liquid-tight conduits.
- F. Contractor shall provide all lubricants required for initial start-up of the equipment.
- G. All field painting shall be in accordance with Section 09 90 00 Painting of these Specifications.

3.2 FIELD TESTING

- A. The equipment Supplier shall provide one (1) day of factory start-up by a factory service representative. The factory representative shall fully inspect and certify in writing to the Engineer that the equipment installation is acceptable to the equipment Manufacturer prior to acceptance by the Owner.
- B. All pumping systems shall be pressure tested for leaks. All systems shall be flushed prior to start-up.
- C. Following installation, the Contractor shall operate the equipment continuously without overheating, leakage, excessive wear, vibration or noise for a period of six (6) hours to demonstrate satisfactory installation and performance to the Engineer.
- D. If required, the Contractor shall make all necessary changes to the installation to provide satisfactory operation at no additional increase in Contract Price or Contract Time.

3.3 FACTORY TRAINING

- A. The equipment Manufacturer shall provide the services of a field representative for the purpose of instructing and assisting the Contractor and the Owner's personnel in the proper use of the equipment.
- B. The equipment Manufacturer shall furnish operating and maintenance instructions for the equipment for the Contractor per Section 01 70 00 of these Specifications.

END OF SECTION

SECTION 46 43 21
CIRCULAR CLARIFIER EQUIPMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install complete, ready for operation and field test two(2) pier supported, scraper type, circular sludge collector, as shown on the Contract Drawings and as specified herein. The collector shall comprise of a complete assembly including access walkway, center drive assembly, center pier, influent well, EDI well, drive cage, sludge collector arms, skimmer/scum trough, and necessary anchorage parts and control panel.
- B. The collectors shall be designed for installation in the following:
 - 1. One (1) 50-foot diameter circular tank with a 12'-0" side water depth with a floor slope of 1" to 12".
- C. These Specifications are intended to give a general description of what is required, but do not cover all details that shall vary in accordance with the requirements of the equipment application. It is, however, intended to cover the furnishing, delivery, complete installation and field testing of all materials, equipment and all appurtenances required to complete the Work of this Section, whether specifically mentioned in these Specifications or not.
- D. There shall be furnished two (2) clarifier mechanisms, suitable for installation in a concrete basin as shown on the contract drawings.
- E. Each mechanism shall be a center column supported center feed unit with peripheral effluent collection. A center drive mechanism shall be provided for rotation of the two (2) rake arms with spiral type rake blades.
- F. The equipment shall be designed to effectively settle mixed liquor suspended solids and scrape the settled solids from the basin floor to the sludge sump as shown on the drawings. The clarified effluent shall be collected uniformly by the peripheral launder. Surface scum shall be collected by the scum skimming equipment and discharged through the scum withdrawal pipe.
- G. The equipment furnished for each clarifier mechanism shall include but not be limited to: walkway with handrails, center drive assembly, center drive platform, center support column with inlet openings, flocculating feedwell, inner dispersion inlet well (EDI), center cage, sludge collection arms with spiral rake blades, surface scum skimming equipment, effluent weir plates and scum baffle, peripheral density wall baffles, anchor bolts and assembly fasteners.
- H. Except where specifically indicated otherwise, all plates and structural members designated for submerged service shall have a minimum thickness of 1/4 inch. All structural steel shall conform to ASTM A-36 requirements and steel plate shall conform to ASTM A283C requirements. All anchor bolts used to secure the mechanism to the tank shall be hot dipped galvanized high strength steel. All fasteners shall be high strength steel. Handrail, skimmer, and rake blade squeegee fasteners shall be Type 304 stainless steel.

1.02 RELATED WORK

- A. Division 03 Concrete
- B. Division 05 Metals.

- C. Installation of anchor bolts is included in Division 05 Metals, but anchor bolts shall be furnished within this Specification.
- D. Division 09 Finishes
- E. Electrical work, except as otherwise specified herein, is included in Division 26.
- F. Division 40 Controls

1.03 REFERENCES

- A. American Society of Testing Materials (ASTM):
 - 1. A-36 Structural Steel Specifications
 - 2. 304 Bolt Specifications
 - 3. A-123 Hot-Dip Galvanized Coatings
 - 4. A-153 Hot-Dip Galvanized Bolts
 - 5. A-48 Cast Iron Specifications
 - 6. A-536 Ductile Iron Specifications
 - 7. A-283C Steel Plate Specifications
- B. American Iron and Steel Institute (AISI), Heat Treated Steel Specifications
- C. American Gear Manufacturers' Association (AGMA), Gear Ratings
- D. American Welding Society (AWS), Current Standards
- E. Anti-friction Bearing Manufacturers' Association (AFBMA), Bearing Life Specifications
- F. National Electrical Manufacturer's Association (NEMA), Motor Design Standards and Standards for Control Enclosures

1.04 SUBMITTALS

- A. Submit in accordance with Specification Section 01 33 00 Submittal Procedures, copies of all materials required to establish compliance with this Section.
- B. Certified shop and installation drawings showing materials, details of construction, dimensions and connections to work of other Sections. Submit calculations to the Engineer for approval substantiating the torque output. Include in the submittal calculations on the worm gear set and bearings used in the gear reduction unit.
- C. Complete operating and maintenance instructions shall be furnished for all equipment included under these specifications in accordance with Specification Section 01 70 00 Execution and Closeout Requirements.
- D. The Contractor shall submit complete shop drawings of all equipment furnished for this project as covered by these specifications. The Contractor's submittal must include a certification that the submitted material describes exactly the equipment to be provided. Substitutions of equipment subsequent to submittal approval shall not be accepted.
- E. The clarifier equipment Manufacturer shall furnish as a minimum the following design and description information to establish compliance with the following specifications.
 - 1. Certified general arrangement and tank dimensional drawings.

2. Certificate of design stamped by a Registered Professional Engineer stating that the equipment to be provided for this Project meets or exceeds all design requirements of these specifications. The certificate shall state the respective loads and design criteria.
3. Drive mechanism rating calculations, stamped by a Registered Professional Engineer, verifying the compliance of the drive gears and bearings with the specified continuous torque rating and bearing life rating.
4. Motor data and catalog information. Electrical drawings as applicable to the supply of the clarifier equipment Manufacturer.
5. Catalog cut sheets for purchased sub-components.

1.05 QUALITY ASSURANCE

A. Qualifications

1. All equipment and appurtenances furnished within this Specification shall be furnished by a single Manufacturer who is fully experienced, reputable and qualified in the manufacture of the equipment to be furnished.
2. The equipment shall be designed, constructed and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Contract Drawings.
3. The clarifier equipment Manufacturer shall modify their standard equipment to meet the minimum values specified for dimensions, design, and the intent of this Specification.
4. Manufacturers regularly engaged in the manufacture of the clarifier equipment as specified herein and who can demonstrate equipment of this specified design, in actual service for a period of not less than five (5) years shall be considered as acceptable Manufacturers.
5. Manufacturers shall show evidence of quality assurance in manufacturing and supplying equipment essential in details to the equipment herein specified.
6. Manufacturers not named in this Specification and meeting the requirements, as set forth in Paragraph C and D, must submit to the Engineer detailed information describing how their proposed equipment shall meet this Specification, fifteen (15) working days prior to the bid date. The detailed information shall include, but not be limited to dimensional data, materials of construction and an installation list with address, telephone number, and an individual's name directly employed by the owner of the equipment. Plan holders shall be notified of approved Manufacturers by addendum, five (5) working days prior to bid date.

1.06 OPERATION AND MAINTENANCE (O&M) MANUALS

- A. O&M manuals shall be provided by the clarifier Manufacturer at least two (2) weeks prior to shipment of all major equipment components. Each manual shall be a bound, indexed binder with drawings and parts lists prepared specifically for this project rather than general instructions that are not designed for this project.
- B. As a minimum the O&M manual shall contain the following.
 1. Certified as-built drawings (general arrangement and general arrangement detail drawings)
 2. Erection drawings
 3. A complete bill of materials for the equipment including the weights of all structural steel components

4. Installation and maintenance instructions for the specific equipment including the erection sequence, maintenance and trouble-shooting check points, and complete lubrication procedures with recommended grades of lubricants
5. Cut sheets for all equipment items purchased from sub-vendors
6. A list of the clarifier Manufacturer's recommended spare parts specifically denoting wear items, long delivery items, and all items convenient for stocking as optional replacement items

1.07 DELIVERY, STORAGE AND HANDLING

- A. All equipment shall be protected against damage during shipment
- B. Factory-assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Contractor.
- C. Fabricated assemblies shall be shipped in the largest sections permitted by carrier regulations, properly match marked for ease of field erection.
- D. All components shall be erected immediately upon receipt from the clarifier Manufacturer or stored in strict conformance with storage recommendations provided by the clarifier Manufacturer in the operations and maintenance manual.
- E. The mechanism shall be lubricated in strict accordance with the instructions of the clarifier Manufacturer's field service representative. The required lubricants shall be provided by the Contractor.

1.08 GUARANTEE

- A. The equipment and installation shall be fully guaranteed by the Contractor for a period of one (1) year from the date of Substantial Completion. The guarantee shall cover any and all defects in workmanship or materials that may develop in this specified time. Refer to Division 01 General Requirements of these Specifications for additional information.

1.09 SERVICE REQUIREMENTS

- A. Number of eight-hour days Four (4)
- B. Number of trips to jobsite Four (4)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Ovivo, USA (formerly EIMCO Water Technologies).
- B. Walker Process

2.02 DESIGN CRITERIA

- A. Provide two (2) circular sludge collectors (secondary clarifier) that meets the following criteria.
 1. Basin diameter.....50'-0"
 2. Side water depth.....12'-0"
 3. Tank freeboard 24"
 4. Floor slope.....1:12
 5. Center column diameter 20"
 6. Feedwell diameter 13'-0"

7. Feedwell submerged depth 4'-0"
8. Energy dissipating inlet (EDI) diameter 5'-0"
9. EDI submerged depth 2'-0"
10. Number of baffled EDI openings Four (4)
11. Cage minimum size 2'-10" square
12. Rake arm minimum size 2'-10" square
13. Spiral blade height at tank wall 5"
14. Spiral blade height near tank center 18"
15. Scum box width 3'

- B. The circular sludge collector shall be capable of efficiently collecting and removing settled sludge.
- C. It shall be the responsibility of the Contractor and sludge collector Manufacturer to closely inspect the Contract Drawings and coordinate the equipment selection for approval by the Engineer.

2.03 CONSTRUCTION

A. General

1. Circular sludge collectors shall include but not be limited to, access bridge/walkway with handrails and toe plates, center drive unit, sludge collector rake arms, anchor bolts, control panel and other appurtenances as required for a complete and operable system.
2. Chains, sprockets, bearings or gearing shall not be located below the water surface and shall not come in contact with the process liquid.
3. No underwater bearings to carry any part of the vertical thrust load shall be allowed.
4. All unspecified fasteners and anchor bolts used in the assembly and installation of the equipment shall be Type 304 stainless steel.
5. Each clarifier mechanism shall be of the center drive type, supported on a stationary influent column, with the flow entering at the bottom of the influent column and flowing upward to the inlet openings and dispersed into the tank through the EDI and flocculating feedwell. The clarifier shall be designed to remove sludge uniformly from the bottom of the tank.

B. DRIVE MECHANISM

1. Drive mechanism shall be rated for 17,100 ft-lbs AGMA 20 years continuous torque, 25,000 ft-lbs for 100% design torque and 68,000 ft-lbs for momentary peak torque.
2. The center drive assembly shall consist of an integral motor and primary speed reducer coupled through roller chain and sprockets to a secondary worm/worm gear reducer driving the main gear through a pinion and shall have an integral overload protection system. The intermediate worm gear reduction unit and final gear reduction unit shall be the product of the Equipment Manufacturer. Units purchased from a third party Manufacturer shall not be acceptable.
3. All gears and bearings shall be oil bath lubricated with the main bearing totally submerged in oil and the teeth of the main spur gear submerged at least 70 per cent in the oil bath. Oil pumps for lubrication or grease lubricated bearings are not considered appropriate for this application and will not be allowed. The oil reservoir for the main bearing and gear shall have a section of minimum depth 5 inches below the main bearing to positively prevent contamination of the

main bearing and gears with condensate or other contaminants. Gear and bearing housings must also be fitted with oil level sight glasses and condensate drains. Condensate must be allowed to drain from a low point of the housing. Condensate and contaminants will not be allowed to drain through the lower pinion bearing.

4. Drive components will be located via a machined, registered fit to preserve the alignment of key drive components under all load conditions. Inspection of the completed drive unit shall be accomplished at the clarifier manufacturer's shop, with reports of all tests and certifications of material hardness being made available for review at the Engineer's request prior to shipment to the job site.
5. Major drive components, main gears and bearings must be designed to allow for separate and individual replacement by plant personnel to facilitate quick and economical repairs.
6. The complete center drive assembly, including the overload protection device, shall be a regularly manufactured in-house product of the clarifier Manufacturer. The center drive assembly is a key element in a successful clarifier installation, therefore drive assemblies purchased from third party vendors will not be accepted.
7. The drive motor shall be minimum 3/4 horsepower and shall be totally enclosed, fan cooled, with a 1.15 service factor, and have bearings with a minimum B10 rating of 50,000 hours. Operating electric current will be 230/460 volt, 3 phase, and 60 hertz. Each motor will be NEMA Design B employing Class F insulation designed for an ambient temperature of 40°C.
8. The gearmotor primary speed reducer shall drive a secondary worm gear reducer through a #60 roller chain and steel sprockets enclosed in a galvanized 22 gauge steel guard. A constant speed motor shall drive the speed reducer. Sprockets and chain shall be designed for the connected horsepower of the drive with a minimum service factor of 4.0. Provision shall be made for adjustment of chain tension.
9. The main drive unit shall consist of a worm gear secondary reduction unit, pinion and main spur gear assembly. The secondary reducer shall be a worm/worm gear reducer specifically designed for this application. The worm gear shall be centrifugally cast high strength manganese bronze. The worm shall be hardened alloy steel. A single piece pinion shall be keyed to the worm gear to transmit power from the worm gear to the spur gear. In order to maintain proper alignment between the pinion and the spur gear, the pinion will be supported by bearings both above and below the spur gear. The bearings shall be fitted into precision machined bearing pilots to positively insure bearing and gear alignment.
10. The main spur gear material shall be high strength ductile iron per ASTM A536 grade 100-70-03 or equal. The gear shall have a nominal pitch diameter of 35 inches with a 4.75 inch face width or the equivalent nominal spur gear surface area of 447 square inches. Spur gear surface area is defined as the spur gear pitch diameter multiplied by the spur gear face width multiplied by 3.14.
11. The main gear shall rotate and be supported on a ball bearing assembly provided with four replaceable liner strips fitted into the main gear and turntable base. Liner strips shall be special vacuum degassed carbon corrected alloy steel hardened to a Rockwell hardness of at least 43 to 46 RC. The turntable base shall be a minimum 1 inch thick to insure adequate structural rigidity to properly support the drive bearing and gear.
12. The main gear and bearing shall be completely enclosed in an ASTM A-48 Class 40A cast iron housing provided with neoprene dust seals. In order to ensure the maximum possible base rigidity and vibration dampening, the gear housing shall be of full sidewall construction, integral with the base. Prior to assembly, the base shall be thoroughly inspected for seep holes

or inclusions and given a hydrostatic test to insure no leaks are in the oil containment area. Shop inspection reports must be made available for review.

13. The drive unit shall be equipped with an electro-mechanical overload control device actuated by thrust from the worm shaft. The pointer shall provide a visual reading of the relative main gear output torque on a 0 to 100 percent graduated scale. The 100 percent reading shall equal the 100 percent drive rating as specified in Subsection 2.03. The control device shall also activate an alarm switch for warning of impending overload, a motor cutout switch for overload protection and a back-up safety motor cutout switch for back up overload protection. In lieu of a back-up safety motor cutout switch a slip clutch assembly will be acceptable upon review by the Engineer. The respective switches in the overload control device shall be factory calibrated and set to the following settings:
 - a. Alarm: 40% of scale
 - b. Motor cutout: 85% of scale
 - c. Back-up motor cutout or slip clutch: 100% of scale.
14. All drive control components shall be mounted in a weatherproof enclosure of either epoxy coated aluminum construction or stainless steel with a gasket-sealed, removable cover. The pointer shall be covered with a clear plastic enclosure and shall be above the walkway surface for visibility from the walkway. Amperage sensing devices are not acceptable for torque overload protection due to their inability to react quickly enough to prevent damage to the drive. Overload devices with exposed linkage connections will not be accepted due to possible corrosion problems. Devices which react to rotational movement of the secondary reduction unit will not be allowed due to possible misalignment of gearing created by the movement of the reduction unit.
15. The center drive unit shall be designed for the continuous torque rating as specified in section 1.03. The continuous torque shall be defined as the minimum torque at which the drive mechanism may operate continuously 24 hours per day, 365 days per year, for 20 years, at the specified sludge collector arm speed. Main gear and pinion calculations shall be based upon ANSI/AGMA 2001-C95 standards for rating the pitting resistance and bending strength of involute spur and helical gear teeth. Calculations shall clearly present the values used for the following design parameters:
 - a. Number of pinions
 - b. Actual face width
 - c. Tooth geometry (I and J factors)
 - d. Load distribution factor
 - e. Allowable contact stress
 - f. Allowable bending stress
 - g. Pinion pitch diameter
 - h. Hardness ratio factor
 - i. Elastic coefficient
 - j. Life factor
16. The load distribution factor shall be determined by the empirical method. For parameters which are material dependent, such as allowable contact stress, the calculations shall include a complete description of material and heat treatment used.

17. Worm gearing shall be designed and rated to equal or exceed the specified continuous torque and life. The basis for rating shall be ANSI/AGMA 6034-B92 standards for durability rating and design of worm gear reducers.
18. The continuous torque rating for the drive unit shall be the lowest value determined for the gearing.

A. WALKWAY ACCESS BRIDGE

1. The clarifier shall be provided with a 36-inch clear open width walkway extending from the tank wall to the center drive platform. The walkway shall be supported at the center by the drive unit and supported on the opposite end by the tank wall. As a minimum, the walkway shall be designed to safely withstand all dead loads plus a live load of 50 pounds per square foot with a maximum deflection of 1/360 inch, over the entire span. The walkway shall consist of beams or a structural steel truss, with either sufficiently braced to resist the specified design loads. The walkway decking shall be 1-1/4 inch aluminum I-Bar grating. Coordination with the Contractor is required to ensure step shall have proper fit at the site.
2. The bridge shall span the width of the tank. The bridge shall be designed to prevent lateral movement of the bridge at the outer wall.
3. A center drive operations platform shall be provided. It shall be a minimum of 8 feet square to provide clearance around the center assembly and drive control for maintenance and service. The drive platform shall be decked with 1-1/4 inch aluminum I-Bar grating and have sufficient structural steel supports to meet the specified design load conditions.
4. Provide handrails with toe plate along both sides of the walkway and around the center drive platform. Handrails shall be constructed with 1-1/2-inch diameter Schedule 40 aluminum, 3-rail handrail and a 4-inch high aluminum toe plate extending along both sides of the bridge. The handrailing shall be in conformance with Section 05 50 00 Metal Fabrications of these Specifications, and shall be as shown on the Contract Drawings.
5. All dissimilar materials (e.g., aluminum vs. steel or concrete) shall be isolated from contact by 0.030-inch thick neoprene gaskets.
6. Anchor bolts shall be sized and furnished by the Supplier. All bolts, washers and hex nuts shall be Type 304 stainless steel unless noted otherwise. All anchor bolts shall be set by the Contractor with all equipment placed on foundations, leveled, shimmed, bolted down and grouted with a non-shrink grout.

B. CENTER CAGE

1. The center cage shall be of steel box truss construction, with connections for the two (2) sludge removal arms and feedwell supports. The top of the cage shall be bolted to the main gear which shall rotate the cage with the attached arms and feedwell. The minimum angle size used for construction of the cage and rake arms shall be 2-inch x 2-inch x 1/4-inch members.

C. SLUDGE COLLECTOR RAKE ARMS

1. Each clarifier mechanism shall include two (2) sludge removal arms of steel truss construction, with steel spiral rake blades and adjustable 20 gauge, Type 304 stainless steel squeegees. The rake blades shall provide complete raking of the basin floor twice per revolution.
2. The rake blades shall consist of a minimum 3/16 inch thick steel plate. The blades shall be constructed to a logarithmic spiral curve with a constant 30 degree angle of attack. Blade depth shall vary as noted in Subsection 2.03 above. Each rake truss support arm shall be provided with the necessary outrigger bracing and other blade support structures, to ensure that the complete blade can be properly located and adjusted in the field.

3. The rake blades shall terminate in the center to within 1 inch of the rotating sludge collection drum.
4. The structural calculations for the rake arm shall include an analysis of the torsional loads from the spiral curve blade.
5. The cage and rake arms shall be designed such that calculated stresses do not exceed the AISC allowable stress at the drive 100% rating.

D. CENTER COLUMN

1. A stationary center column shall be provided which shall serve as the influent pipe. One end shall have a 1-1/4 inch support flange for bolting to the foundation with a minimum of eight (8) 1-1/4 inch diameter anchor bolts as shown on the plans. A similar flange shall be provided at the top of the column for supporting and securing the center drive assembly. Minimum center column thickness shall be 1/4 inch.
2. Influent openings shall be provided in the upper portion of the column to allow unrestricted passage of the flow into the energy dissipating feedwell. Influent velocity shall be reduced by providing a total inlet port area a minimum of 135 percent of the center column cross sectional area.

E. ENERGY DISSIPATING INLET (EDI)

1. The clarifier shall be equipped with an energy dispersion well located inside the rotating flocculation feedwell. The dispersion well shall be designed to dissipate the energy of the incoming flow by way of multiple baffled inlet ports equally spaced around the dispersion well.
2. The energy dissipating inlet shall consist of an internal distribution EDI well and an outer flocculating feedwell. The centrally located EDI well shall be at a minimum 5'-0" diameter and 2'-0" deep supported by and rotate with the drive cage.
3. The center dispersion well shall include a bottom plate to fit within one inch of the center column. The well shall be constructed of 3/16 inch plate. EDI outlet ports equally spaced around the periphery shall be provided for energy dissipation. The outlet ports shall impart a tangential flow into the outer flocculating feedwell and shall have bottom plates to prevent short circuiting.
4. The bottom plate of the EDI shall be provided with properly sized drain holes.

F. FLOCCULATING FEEDWELL

1. The flocculating feedwell shall be supported by structural members attached to the rotating center cage. The feedwell shall be fabricated out of 3/16 inch steel plate with upper and lower reinforcing rim angles and stiffeners as required. Properly sized scum ports shall be equally spaced around the feedwell periphery to allow scum to exit from the feedwell at water level.
2. The outer flocculating feedwell shall not be less than 13-feet in diameter and 4-feet in side depth.

G. SCUM BOX

1. Surface scum skimming equipment shall be furnished with the clarifier mechanism. It shall be arranged to have the surface scum swept along an angled skimmer blade to the skimmer assembly, attached at the end of the blade, for discharge to the scum box as shown on the plans. The surface of the clarifier shall be swept once per revolution.
2. The skimmer blade shall be tangential to the rotating feedwell and be supported by vertical supports from the rake arm. The skimmer assembly shall be a pivoting aluminum skimmer device equipped with manual out-of-service lock out. The skimmer shall have replaceable

neoprene rubber wipers on all three sides to form a pocket to trap the scum and discharge the scum into the scum box.

3. The scum box shall be supported from the tank wall and connected to a six (6) inch scum line, as shown on the contract drawings.
4. The clarifier equipment manufacturer shall furnish a flush valve assembly for automatic flushing of the scum box and scum pipe. The flush valve assembly shall be adjustable to allow 0 to 20 gallons of clarified effluent to enter the scum box as the skimmer assembly passes over the scum box. The assembly shall consist of a stainless steel lever, UHMW seal plate and neoprene diaphragm mounted to the scum box. The diaphragm shall be opened and closed by an easily adjustable, submerged actuation arm mounted to the rotating skimmer blade. The flush volume adjustment mechanism shall be above the water level and shall include at least three settings.

H. EFFLUENT WEIR AND SCUM BAFFLE

1. Effluent weir plates shall consist of 9 inch deep x 1/4 inch thick FRP sections with 2-1/2 inch deep 90-degree V notches at 6-inch intervals. The weir sections shall be fastened to the tank wall using Type 304 stainless steel cinch anchor bolts hex nuts and 5-inch diameter FRP washers, allowing for vertical adjustment. To prevent leakage all surfaces between the launder walls and weir plates shall be given a seal coat of suitable mastic by the erection Contractor.
2. The scum baffle plates shall consist of 12 inch deep x 1/4 inch thick FRP sections supported from the tank wall by FRP angle brackets secured with Type 304 stainless steel cinch anchor bolts and hex nuts, allowing for vertical and radial adjustment.

2.02 SURFACE PREPARATION AND PAINTING

- A. All field welds or marred areas shall be mechanically wire brushed to remove slag and surface impurities. Final surface preparation is required to remove all foreign matter, dust or other products from the primed coat.
- B. All non-submerged steel shall be sandblasted to SSPC-SP 6 specifications and given one coat of Manufacturer's epoxy primer 2.0 to 3.0 mils DFT. All submerged steel shall be sandblasted to SSPC SP 10 specifications and given one coat of Manufacturer's epoxy primer 2.0 to 3.0 mils DFT.
- C. Prior to assembly of the drive unit, the castings shall have been sandblasted and thoroughly cleaned to remove any foreign particles in the drive base. After assembly, the drive mechanism shall be solvent cleaned and power wire brushed as needed prior to application of Manufacturer's standard primer and finish paint.
- D. Gear motors shall be furnished with Manufacturer's standard enamel.
- E. All motors, reducers, gearboxes and other equipment shall be final coated also with same mil thickness unless noted otherwise on the Contract Drawings.

2.03 SPARE PARTS

- A. Provide the following spare parts.
 1. One (1) sight glass or dip stick for each main drive housing containing oil.
 2. One (1) set of neoprene skimmer wipers for each mechanism.

2.04 CONTROLS

- A. Furnish one (1) control panel for each collector. The control panel enclosure shall be NEMA 4X, Type 316 stainless steel. The control panel shall contain the following.
 1. Power disconnect switch (lockable)

2. Start/Stop pushbuttons for manual operation.
 3. Red stop indicator light
 4. Green run indicator light.
 5. Yellow high torque indicator light
 6. Red alarm beacon light on top of panel.
 7. Dry contact for common alarm to plant SCADA system.
 8. Electrical schematic and terminal strips as required.
- B. The motor starter shall be located in the MCC for each clarifier drive. The control panel shall be prewired and tested by the Manufacturer for operation. The wiring shall be in accordance with current national electric code. All electrical components shall be labeled to agree with the electrical schematic. The panel shall be of sufficient size to contain all controls and wiring. The panel shall be mounted to the clarifier bridge adjacent to the drive mechanism.
- C. The Contractor shall mount the control panel, furnish the power feed lines and conduit to the control panel and from the control panel to the drive unit.

PART 3 EXECUTION

3.01 INSTALLATION

- A. All equipment shall be installed in accordance with the Manufacturer's requirements. The controls shall be easily accessible and walking areas unobstructed.
- B. The Contractor shall place the anchorage in accordance with certified prints supplied by the Equipment Supplier.
- C. The equipment supplier shall provide two (2) days of field installation supervision to assist the Contractor. The field inspection shall be performed by a factory service engineer familiar with the product line.
- D. All electrical conduits shall be connected to the motors with flexible liquid-tight conduit.
- E. Contractor shall provide all lubricants required to allow initial start-up of the equipment.
- F. The equipment shall be erected in strict accordance with the Manufacturer's recommendations. A 2-inch thick layer of grout shall be applied to the tank floor in strict accordance with the Manufacturer's recommendations. Screenshot boards shall be supplied by the erecting Contractor.

3.02 FIELD TESTING

- A. The equipment supplier shall provide one (1) day of factory start-up by a factory service engineer. The factory engineer shall fully inspect and certify in writing to the Engineer that the equipment installation is acceptable to the equipment Manufacturer prior to acceptance by the Owner.
- B. Following installation, the Contractor shall operate the equipment continuously without overheating, leakage, excessive wear, vibration or noise for a period of three (3) consecutive days to demonstrate satisfactory installation and performance to the Engineer.
- C. If required, the Contractor shall make all necessary changes to the installation to provide satisfactory operation at no additional increase in Contract Price or Contract Time.

3.03 TRAINING

- A. The equipment Manufacturer shall provide the services of a field service representative for the purpose of instruction and assisting the Contractor and the Owner's personnel in the proper operation of the equipment.
- B. The equipment Manufacturer shall furnish operating and maintenance instruction for the equipment for the Contractor per Section 01 70 00 Execution and Closeout Requirements of these Specifications.

3.04 SERVICE

- A. The equipment Manufacturer shall provide a service representative properly trained in inspection and operation of the mechanism to approve the installation, certify that the torque settings of the drive overload protection device are correct, perform the torque test and instruct the owner's personnel on maintenance and operation. If additional service is required due to the mechanisms not being fully operational, at the time of service requested by the Contractor, the additional service days shall be at the Contractor's expense.

3.05 TORQUE TEST

- A. The clarifier mechanism shall be field torque tested. The purpose of the torque test is to verify the structural integrity of the mechanism structural steel design and center drive unit. The testing shall be carried out under the supervision of the equipment Manufacturer's representative and as approved by the Engineer before the mechanisms are accepted and placed into operation.
- B. The torque test shall consist of securing the rake arms by cables to anchor bolts installed by the Contractor in the tank floor at locations specified by the equipment Manufacturer. A load shall be applied gradually to the scraper arm by means of a ratchet lever and cylinder connected to the cable assembly.
- C. The magnitude of the applied load shall be measured by calculating the torque from the distance of the line of action of each cable to the center line of the mechanism. A reading shall be taken at the 100% value of the drive design torque.
- D. The Manufacturer's service representative shall verify that the alarm, motor cut-out, and backup safety motor cut-out switches are properly set and are in proper operation to protect the clarifier mechanism as specified.

END OF SECTION

SECTION 46 53 61

OXIDATION DITCH EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish and deliver an Oxidation Ditch type aeration system capable of performing as specified herein. Equipment components shall conform to the specific requirements of this Specification.
- B. Oxidation Ditch Supplier shall provide process design and equipment procurement, furnish and deliver all equipment and accessories to the project site, and provide all necessary services as specified herein. The scope of supply shall include, but is not limited to, the following major items.
 - 1. One (1) 50 horsepower low speed, fixed, mechanical surface aerator. Each aerator shall consist of a drive motor, gear reducer, coupling, shaft, surface impeller, a submerged radial pumping impeller and appurtenances, including the Excell® Velocity Enhancer.
 - 2. One (1) 50 horsepower low speed, fixed, mechanical draft tube aerator. Each aerator shall consist of a drive motor, gear reducer, coupling, shaft, surface impeller.
 - 3. One (1) Manual Weir Gate Each gate shall consist of a gear reducer, stand, shaft and gate assembly.
 - 4. Instrumentation, including two (2) Dissolved Oxygen (DO) probes.
 - 5. One (1) Motor Control Panel (MCP) with Variable Frequency Drives (VFD) and one (1) Oculus™ Control System consisting of monitoring for the DO loop, aerator VFDs, level sensor, and control logic for the Carrousel basin process.
 - 6. Installation, check-out, start-up, testing and continuing operations support services.
 - 7. Redundant components and spare parts as specified.
- C. All equipment specified within this Specification shall be furnished by a single Manufacturer (the Aeration Equipment Manufacturer) fully experienced, reputable, and qualified in the manufacture of the equipment specified. The basin has been designed to accommodate equipment supplied by Ovivo USA, LLC.
- D. Related Sections:
 - 1. Section 01 70 00 Execution and Closeout Requirements

1.02 SUPPLIER

- A. Ovivo USA, LLC
- B. Pre-qualified engineer-approved equal.
- C. Pre-qualified engineer-approved equal manufacturers or suppliers wishing to be considered for this project shall submit to the Engineer at least two (2) weeks prior to Bid Date a full qualification package detailing full compliance with this specification. Manufacturers that do not meet the performance, experience, and quality requirements of this project shall not be pre-

approved. Any alternative Manufacturers gaining approval by the Engineer shall be identified via Addendum prior to the Bid Date.

1.03 OXIDATION DITCH AEARTION SYSTEM DESIGN CONDITIONS

A. Influent Conditions

1. Number of Basins..... One (1)
2. Average Daily Flow (ADF)..... 1.5 mgd
3. Maximum Daily Flow (MDF)..... 1.7 mgd
4. Peak Hourly Flow (PHF)..... 1.75 mgd
5. BOD5 Load (ADF)..... 70 mg/L
6. TSS Load (ADF) 50 mg/L
7. TKN Load (ADF)..... 35 mg/L
8. NH₃-N Load (ADF) 30 mg/L
9. Phosphorus Load (ADF) 4 mg/L

B. Plant Effluent Limits (average daily conditions)

1. BOD5 (After Filtration)..... 4 mg/L
2. TSS (After Filtration) 5 mg/L
3. NH₃-N..... 1.0 mg/L
4. Total P 0.33 mg/L (with chemical addition)

C. Site Conditions

1. Wastewater temperature
 - a. 20°C (maximum)
 - b. 10°C (minimum)
 - c. 18°C (average)
2. Site elevation: 1,500 feet above sea level
3. Ambient air temperature
 - a. 95°F (maximum)
 - b. 5°F (minimum)
 - c. 55°F (average)

D. No inhibition by toxic pollutants.

E. Wastewater will pass through fine screens with 3 millimeter clear openings and grit chambers prior to the Oxidation Ditch.

F. Organic Loading: 12.0 lbs BOD5/1,000 cubic feet/day

G. Aerobic SRT: 11.5 days

- H. Mechanical Aeration SAE (MIN): 3.5 lb O₂/HP-hour
- I. Hydraulic Retention Time:.....8.7 hours
- J. Wastewater beta (β) value:.....0.97
- K. Wastewater alpha (α) Value:.....0.93
- L. Tank Geometry
 - 1. Aeration Tank
 - a. Water Depth: 16 feet
 - b. Freeboard:.....1.5 feet to 2.0 feet
 - c. Volume: 0.54 million gallons
- M. Design Criteria
 - 1. Number of Aerators: Two (2) (One [1]Excell Aerator PRO w/ Excell Velocity Enhancer (EVE) & One [1] Excell Aerator PRO w/ draft tube)
 - 2. Motor Hp/Aerator:.....50
- N. Process Requirements
 - 1. Minimum DO: 2.0 mg/L at average load, average water level, and maximum wastewater temperature measured at the aeration zone discharge.
 - 2. MLSS shall not exceed 4,500 mg/L.
 - 3. Minimum mixing velocity: 0.5 feet per second at all points in basin during aeration.
 - 4. Design to ensure nitrification under minimum wastewater temperatures.

1.04 REFERENCES

- A. American Gear Manufacturers Association (AGMA)
- B. National Electrical Manufacturers Association (NEMA)
- C. American Federation of Bearing Manufacturers Association (AFBMA)
- D. American Society for Testing and Materials (ASTM)
- E. American Welding Society (AWS)
- F. Steel Structures Painting Council, American National Standards Institute (SSPC)

1.05 SUBMITTALS

- A. Shop drawing submittals shall include at least the following.
 - 1. Certified shop and erection drawings showing all important details of construction dimensions, anchor bolt locations, aerator impeller diameter, aerator impeller rotational speed (rpm), aerator impeller tip speed (fps), and field connections.

2. Descriptive literature, bulletins, and catalogs of the equipment, including details of the dry well and gear reducer lubrication points.
 3. Installation, operation, and start-up procedures including lubrication requirements.
 4. Complete motor data.
 5. Total weight of the equipment including the weight of the single largest item.
 6. A complete bill of materials for all equipment with the O&M manual. No samples shall be required.
 7. A list of spare parts that are supplied with the project.
 8. Oxygen transfer efficiency test reports from a minimum of two (2) separate installations within the United States per Subsection 1.05.B of this Specification.
 9. Written certification from the Aerator Manufacturer that the proposed aerators are guaranteed to meet the specified velocity requirements. Shop drawings shall not be reviewed without this certification.
 10. Installation list with a minimum of ten (10) operating installations in an oxidation ditch configuration using dual impeller aerators operating for a minimum of three (3) years within the United States. One (1) additional installation list is required which includes a minimum of three (3) separate sites where draft tube aerators were used in an oxidation ditch configuration and have been operating for at least three (3) years. Submittals shall not be reviewed without compliance with this requirement.
- B. Aeration Equipment Manufacturer must have experience providing process equipment and control systems applicable to this project. The Aeration Equipment Manufacturer must submit the following information and meet the experience requirements specified below.
1. Test reports (different sites) from two (2) full-scale oxygen transfer tests in oxidation ditches with aerators of similar size installed. If the Aeration Equipment Manufacturer cannot supply a test report for a dual impeller aerator in a full-scale oxidation ditch the Aeration Equipment Manufacturer must supply surface impeller-only aerators with in-channel submersible mixers for this Project per Subsection 1.05.C of this Specification. The Manufacturer must still provide two (2) test reports on surface impeller-only aerators per items b through d below.
 - a. At least one (1) test shall be from an installation that has a dual impeller aerator of the same make (number of blades, impeller design).
 - b. At least one (1) test report shall be a full scale clean water non-steady state oxygen transfer test, in compliance with ASCE 2-06, and witnessed and certified by one of three third parties – Stenstrom, Rosso, or Redmon. Steady-state testing or mixed liquor endogenous test methods are not allowed to meet this requirement.
 - c. Results from aerators in square tanks or other facilities which are not full-scale operating oxidation ditches are not acceptable.
 - d. Test results must be in U.S. standard units of 1 atm, 20°C, alpha=1.0, beta=1.0, DO=0. Temperature shall be corrected with an Arrhenius coefficient of 1.024 and alpha and beta shall be measured on site if the test was performed using dirty water test methods.

- e. Minimum standard oxygen transfer efficiency of the surface impeller shall be 3.5-lbs O₂ per motor HP-hour. Motor cut sheets shall be included to document efficiency used to convert wire to motor HP.
- C. Designs that do not incorporate the surface and the submerged impellers on a common shaft must be submitted as alternate equipment, at least two (2) weeks prior to the Bid Date. The alternate submittal must include, but not be limited to the following.
 - 1. Submersible propulsion mixers installed in each channel to achieve 0.5 fps velocity when the water level is below the surface impeller.
 - 2. Additional walkways, a hoist for each mixer, and shall detail all components of the design. Submersible mixers must be fixed to support walkways which span the oxidation ditch channel and positioned at the midpoint of each channel in which the submersible mixers are installed.
 - 3. Power calculations, for a 20-year life cycle, shall be included with this submittal. Design calculations for the additional walkways, point loads on the slab and wall, handrail/stair designs, electrical power supply including conduit and wire sizes, and instrumentation details shall be included in this submittal.
 - 4. All reinforcing layout, pile design and layout, and buoyancy calculations, all certified by a registered professional engineer in the State in which the project is located. All additional costs resulting from the bid of the alternate system, including structural, mechanical or electrical changes, or revisions to the drawings, shall be the sole responsibility of the Contractor. Failure to submit these calculations for an alternate system two (2) weeks prior to the Bid Date shall result in non-acceptance of the alternate system.
- D. Only impeller types which have been tested and certified by the independent consulting, DHV (the inventors of vertical shaft oxidation ditches), shall be acceptable on this project. There are eight (8) impeller types which have been approved by DHV. A letter from DHV stating that the impeller type has been approved for use in oxidation ditch systems shall be submitted to the contractor. This certification shall not require a separate license fee.

1.06 TRANSPORTATION

- A. Provide transportation of all equipment, materials, and products furnished to the job site. Coordinate transportation with the Contractor's installation schedule.
- B. Suitably box, crate, or otherwise protect all equipment during transportation.
- C. Ship and deliver all equipment in the largest assembled sections practical or permitted by carrier regulations to minimize the number of field connections.
- D. Ensure that the equipment is assembled and transported in such a manner so as to clear buildings, power lines, bridges, and similar structures encountered during shipment or delivery to the site of the work.

1.07 OPERATION AND MAINTENANCE (O&M) MANUALS

- A. Submit one (1) preliminary copy and four (4) final copies of a complete O&M manual covering all equipment and products furnished under this section. O&M manuals shall be assembled in tabbed and indexed 3-ring binders with typed table of contents. Organize manuals into separate

sections for each piece of related equipment. Final operation and maintenance manuals shall be furnished in electronic format as well as hard copy.

- B. Submit operations and maintenance manuals for the equipment in compliance with the Contract documents, 30 days prior to shipment. Manuals shall include:
 - 1. Name, address, and telephone number of the nearest competent service representative who can furnish parts and technical service.
 - 2. Descriptive literature, including illustrations, covering the operational features of the equipment, specific for the particular installation, with all inapplicable information omitted or marked out.
 - 3. Operating, maintenance and troubleshooting information.
 - 4. Complete maintenance parts list.
 - 5. Complete connection, interconnecting and assembly diagrams.
 - 6. Approved Shop Drawings.
- C. Equipment and Systems: Provide the following information for each piece of equipment, each building operating system, and each electric or electronic system.
 - 1. Description: Provide a complete description of each unit and related component parts, including the following.
 - a. Equipment or system function
 - b. Operating characteristics
 - c. Limiting conditions
 - d. Performance data
 - e. Engineering data and tests
 - f. Complete nomenclature and number of replacement parts
 - 2. Manufacturer's Information: For each Manufacturer of a component part or piece of equipment, provide the following:
 - a. Printed operating and maintenance instructions
 - b. Assembly drawings and diagrams required for maintenance
 - c. Wiring diagrams
 - d. List of items recommended to be stocked as spare parts
 - 3. Maintenance Procedures: Provide information detailing essential maintenance procedures, including the following:
 - a. Routine operations
 - b. Troubleshooting guide
 - c. Disassembly, repair, and reassembly
 - d. Alignment, adjusting, and checking
 - 4. Operating Procedures: Provide information on equipment and system operating procedures, including the following.

- a. Start-up procedures
 - b. Equipment or system break-in
 - c. Routine and normal operating instructions
 - d. Regulation and control procedures
 - e. Instructions on stopping
 - f. Shut-down and emergency instructions
 - g. Summer and winter operating instructions
 - h. Required sequences for electric or electronic systems
 - i. Special operating instructions
5. Servicing Schedule: Provide a schedule of routine servicing and lubrication requirements, including a list of required lubricants for equipment with moving parts.
 6. Controls: Provide a description of the sequence of operation and as-installed control diagrams by the control Manufacturer for systems requiring controls.

1.08 STORAGE AND HANDLING OF EQUIPMENT

- A. The Contractor shall store and temporarily support equipment prior to installation in strict accordance with the Manufacturer's recommendations and instructions. Protect all exposed surfaces. Keep records of the storage parameters and the dates that storage procedures were performed. The Contractor shall be responsible for work, equipment, and materials until inspected, tested and finally accepted.
- B. Store gear reducers, motors, VFDs and control system components in buildings or trailers which have a concrete or wooden floor, a roof and fully closed walls on all sides. Protect the equipment from being contaminated by dust, dirt, vibration and moisture.
- C. Temporarily connect equipment with built in space heaters to a power source and keep heaters in operation. Rotate all shafts that have bearings on at least a monthly basis.
- D. Fabricated assemblies shall be shipped in the largest sections permitted by carrier regulations and shall be properly match-marked for ease of field erection. The units shall be erected and lubricated in strict accordance with the instructions of the Manufacturer's field engineer.

1.09 WARRANTY

- A. The equipment supplier shall warrant that its equipment shall be free from defects in material and workmanship; and that it will replace or repair, FCA its factory, any part or parts returned to it which examination shall show to have failed under normal use and service by the user within eighteen (18) months following initial shipment or twelve (12) months following operation start up, whichever occurs first.
- B. Complete warranty work as soon as possible following receipt of notice from the Owner for a warranty claim.

- C. In the event of multiple equipment failures of major consequence during the warranty period, disassemble, inspect, and modify or replace the affected equipment as necessary to prevent further occurrences and reinstate the original warranty.

1.10 PATENTS

- A. Pay all patent fees and royalties and bear all costs incident to the use of any design, process, or product that is the subject of patent or copyright by others.
- B. Indemnify, defend, and hold harmless the Owner and Engineer and their employees and agents from and against all claims, damages, losses, and expenses (including attorney fees and court costs) arising out of the infringement of any patent rights or copyrights incident to the performance of the work.

PART 2 PRODUCTS

2.01 AERATOR DESIGN AND PERFORMANCE

- A. Performance:
 - 1. The surface impeller of the dual impeller aerator shall be capable of delivering an oxygen transfer efficiency of no less than 3.5 lb. O₂/HP-hour based on motor output power at standard transfer conditions. If the Manufacturer cannot provide full documentation as required in Submittals, Subsection 1.05 of this Specification, to demonstrate compliance with this requirement, then the Manufacturer shall perform full-scale tests of oxygen transfer efficiency in the presence of the Engineer.
 - 2. The aeration equipment must be capable of effectively mixing the basin during basin dewatering until the water level in the basin is reduced to a depth of three (3) feet. If this requirement cannot be met with the aeration equipment, in-channel submersible mixers must be included in the equipment Manufacturer's scope of supply per Subsection 1.05.C. of this Specification.

2.02 AERATOR MOTORS

- A. Each aerator shall be driven by a single speed 50 HP, totally enclosed fan cooled, constant torque, premium efficiency motor wired for 460 volt, 60 Hz, 3 phase current and suitable for VFD application with a 2:1 speed turndown. The motors shall be rated at 40°C ambient with Class F insulation and shall have a Class B temperature rise at full load. The motor shall have a service factor of 1.15 on sine wave power and a 1.0 service factor on VFD supplied power and shall comply with the applicable provision of the Standards of NEMA. The minimum AFBMA B10 bearing life shall be 200,000 hours. The nominal motor speed shall be 1,800 rpm.
- B. The motors shall be cast iron construction, Mill & Chemical or Corro-duty, and shall flange-mount to the gear reducer. They shall be mounted in a vertical position to the gear reducer and furnished with a canopy cap (drip cover) and suitable lifting lugs. The motor to gear reducer connection shall be accomplished by the use of a flexible coupling.
- C. Motors shall be suitable for operation in a moisture-laden atmosphere. The conduit boxes shall be gasketed with neoprene or equivalent material, so as to prevent moisture from entering the stator through the conduit box. Stainless steel condensation drains shall be suitably positioned

in the lower external surface, so that any accumulation of moisture can drain from the complete motor housing. Ball bearings shall be supplied and shall be grease-lubricated. Grease reservoirs shall be ample and provisions shall be made for re-greasing with a lubrication system where grease is flushed through the bearings. The winding end turns shall be dipped and baked with a non-hygroscopic varnish, the stator bores and rotor cores shall be coated with epoxy paint. The entire enclosure shall be finish painted by the motor Manufacturer at the factory with a corrosion-resistant paint to provide additional protection against moisture and contaminants. The nameplates shall be stainless steel.

- D. Each motor shall be equipped with a suitably-sized space heater to keep condensation from forming when the motor is not running.
- E. Each motor shall be equipped with a normally closed thermostatic heat protection device to protect the motor from overheating during operation. The unit shall immediately stop the aerator drive motor in the event of excessive heat buildup.

2.03 AERATOR GEAR REDUCERS

- A. Each gear reducer shall be of the helical gear type and shall be sized with a minimum service factor for all components of the reducer of at least 2.0 times the motor nameplate horsepower rating in accordance with applicable American Gear Manufacturers' Association (AGMA) standards 2001-C95 errata June 28, 1990, when each unit is operating at full load motor horsepower, 24 hours a day continuous running under moderate shock loads. The efficiency shall not be less than 94 percent based on the gear reducer input horsepower. The gear reducer shall be specifically designed for the loading associated with aerators and/or mixers.
- B. The gear reducers shall be designed for vertical input and output shaft operation and the housing shall be cast iron construction with provisions for the attachment of suitable lifting devices. Each reduction unit shall have gearing of the helical gear type. Worm gearing shall not be acceptable. The units shall be designed to AGMA Service Classification III. All shafts shall be supported on tapered roller or double spherical roller bearings. Gears and pinions shall be made of alloy steels. Shafting shall be made out of medium carbon steel. The gear teeth shall be through-hardened or carburized. Flame hardened gears shall not be acceptable. All gears shall be made from alloy steels with sufficient hardenability to obtain case and core properties meeting the requirements for grade 2 material in accordance with ANSI/AGMA 2001-C95. The steel alloy shall be selected, and the heat treatment shall be controlled, to obtain a microstructure that meets all the requirements for grade 2 material in accordance with ANSI/AGMA 2001-C95.
- C. All gears shall meet the accuracy requirements for AGMA quality No. Q12 in accordance with ANSI/AGMA 2001-B88. Pitting resistance and bending fatigue resistance shall be rated in accordance with ANSI/AGMA 2001-B88.
- D. All bearings incorporated within the gear reduction unit shall have a rating-life expectancy (B10) of 100,000 hours rating-life expectancy (B10). All bearings shall be of the anti-friction type. Bearing life shall be rated in accordance with ANSI/AFBMA Std. 11-1990 based on operating continuously at the rated full load horsepower and speed.
- E. The lubrication of the speed reducer shall conform to AGMA 9005-E02. A reliable lubrication system shall be provided for the gears and bearings. Lubrication systems which rely wholly or in part upon an oil circulating pump shall incorporate a proven reliable pressure device which

shall immediately stop the driving motor and transmit an alarm signal to the motor control center in the event of insufficient lubrication. Each electrical switch shall be wired to its respective aerator motor control center. External oil cooling shall not be permitted. The unit shall be provided with a dipstick or sight glass to observe oil levels. Oil fill and drain lines shall be sufficient size to permit efficient functioning and shall be located on the gear unit in a position which is easily accessible from the bridge platform. The oil drain piping shall be installed so that a container may be placed under the drain discharge.

1. The Contractor shall supply the first charge of run in oil for the reducers, and if necessary due to run time, the change of oil. The Contractor shall purchase the oil from a local firm selected by the Owner, in accordance with the information in the O&M manual, to assure lubricant compatibility.
- F. All grease lubricated bearings shall have seals to retain the grease. The low-speed shaft shall have grease lubricated bearings and shall have a dry well to prevent oil leakage. The dry well shall be 100% maintenance-free with no wearing parts. The dry well shall be sealed by a non-contact double labyrinth seal with a return drain above. The output end of the well shall include the upper and lower bearing seals and separate oil seal. All grease lubrication pressure lines shall be fed from fittings accessibly located above the platform supporting the mechanism.
- G. The housing shall be constructed of high tensile strength gray cast-iron conforming, at a minimum, to ASTM A48 Class 30 with integral dry well construction to eliminate oil leakage at the output shaft and prevent loss of lubrication in the event of a seal failure. The housing shall be stressed relieved prior to machining. The housing shall be tested to preclude casting porosity or weld defects that could result in oil leakage. Lifting lugs shall be provided on the housing suitably located to enable safe removal of the combined electric motor and gear unit from the supporting platform. Removable inspection cover(s) or inspection port(s) shall be provided.
- H. Each gear reducer shall be mounted on a support with hot dipped galvanized steel bolts. The support shall be mounted on four (4) zinc plated jack studs inserted in the platform structure and designed to withstand all normal operating loads. The jack studs shall have the capability to provide a total vertical adjustment of six (6) inches. The jack stud nuts shall be drilled and tapped with set screws and vibration isolation pads and stainless steel washers shall be provided.
- I. Each gear reducer shall be equipped with a suitable oil immersion-type heater for pre heating the lubrication oil prior to start up after prolonged periods of shut-down in cold weather. The heaters shall have an automatic thermostatic control and shall operate on the control voltage.

2.04 AERATOR SHOP TESTS

- A. The motor and gear reducer assembly shall be trial fit at the factory and match marked for ease of onsite installation. The high speed coupling halves shall be factory mounted and aligned. The Contractor shall be responsible for assuring proper alignment and gap tolerance as set forth in the installation instructions.
- B. The gear reducer shall be run under no load conditions at full speed until the oil temperature has stabilized. The overall lubricant temperature, pressure and sound pressure level shall be recorded during steady-state operation.

- C. After successful completion of the shop test and while the gear reducer is at operating temperature, the lubricant shall be drained and the gear reducer shall be flushed with filtered oil. The flushing oil shall be drained and the gear reducer shall be prepared for shipment.

2.05 ANCHOR BOLTS

- A. Anchor bolts shall be designed by the aerator Manufacturer, then furnished and installed by the Contractor.

2.06 AERATOR IMPELLERS, SHAFTS AND COUPLINGS

- A. The surface impeller shall be of a design approved by DHV for use in oxidation ditch systems and shall provide oxygenation and propulsion of the mixed liquor in the oxidation ditch.
- B. The impeller assembly shall consist of a surface and submerged impeller connected to a common aerator shaft as covered under US Patent No. 4,869,818. The surface impeller shall provide oxygenation and propulsion of the mixed liquor in the oxidation ditch. The submerged radial impeller shall provide additional propulsion of the mixed liquor at the bottom portion of the Oxidation Ditch. The impeller assembly shall operate at a maximum output speed of 55.92 rpm. The surface impeller shall present a minimum amount of edge perpendicular to the flow to prevent any attachment of solid materials. If the submerged impeller is not used, submersible in-channel mixers shall be provided.
- C. Each surface impeller shall be a rim-blade type with ten (10) equally spaced blades and constructed of 1/4-inch thick minimum steel plate. The rim plate shall be submerged at all operating conditions, except during basin draining operations, to reduce the effects of variable loading on the aerator support structure and deck. This shall be clearly shown on the submittal drawings. The impeller blades and disc shall be an integral, shop-welded unit requiring no field assembly or welding.
- D. Each submerged radial impeller shall consist of radial pumping blades and hub that shall be an integral, shop-welded unit requiring no field assembly or welding. Each submerged radial impeller shall draw no more than 15% of the aerator nameplate horsepower at full speed and immersion.
- E. The aerator shaft shall be attached to the gear reducer by a rigid, cast iron flange-type coupling. A retainer plate shall be provided for mounting to the end of the gear reducer output shaft to provide protection against disengagement of the coupling from the gear reducer output shaft. The flanges and flange-type coupling shall be assembled with A325 high strength bolts only. Stainless steel fasteners shall not be acceptable.
- F. All structural steel used in the fabrication of the aerator shall conform to the requirements of "Standard Specifications for Structural Steel" ASTM Specification A36. All shop welding shall conform to the latest standards of the American Welding Society (AWS). Fabricated assemblies shall be shipped in convenient sections as permitted by carrier installations.

2.07 AERATOR SPARE PARTS

- A. One (1) oil sensing cutout switch
- B. One (1) flexible motor coupling shall be provided.

2.08 EFFLUENT WEIR

- A. The effluent weir shall be a rectangular weir plate in accordance with the Contract Drawings and installed by the Contractor.
- B. Oxidation Ditch Supplier Shall provide the design approach for the effluent weir control.

2.09 EQUIPMENT CONTROLS

- A. All equipment used to control the Carrousel BNR control system shall be supplied by the Carrousel BNR system Manufacturer. This is to keep continuity and single source responsibility for the entire system.
- B. The controls shall be designed to provide high reliability. The Carrousel BNR system Manufacturer shall provide the programming with logic functions to match the process and operational requirements of the system. The controller shall allow the system to operate the equipment without excessive speed.
- C. The BNR control panel(s) shall be located in a climate controlled building
- D. Control System shall be fully compatible and communicate with a Cloud Based O&M System. All necessary information for the Cloud Based System that applies to equipment of this section shall be provided by the Manufacturer of this Specification.
- E. Motor Control Panel (MCP)
 - 1. The Carrousel control system shall be integrated in a NEMA 4X Stainless Steel with Air Conditioner gasketed MCP configuration. A 480 volt, 3 phase, 60 Hz feed is required. A main disconnect with security lock-out shall be included. The aerator VFDs, and all BNR motor starters shall be integrated into the MCP. A panel board section shall be provided to allow for power distribution to Control System Instrumentation and BNR motor oil immersion heaters. The MCP shall conform to UL845. The PLC control panel of the MCP shall conform to UL508A.
 - 2. Programmable controller (PLC)
 - a. The PLC shall be Allen-Bradley CompactLogix 5069-L306ER, with discrete inputs and outputs. The CompactLogix shall be backed by a compact flash.
 - b. Discrete input cards shall be rated for 120V and be equipped with 16-points per card. Discrete input cards shall be Allen-Bradley 5069-IA16.
 - c. Discrete output card shall be relay-type, rated for 120V and be equipped with 16-points per card. Discrete output cards shall be Allen-Bradley 5069-OW16
 - d. Analog cards shall be rated 4-20 mA. Each input shall be protected by a surge protection device. Analog cards shall be Allen-Bradley 5069-IF8
 - 3. Human Machine Interface (HIM)
 - a. The HIM shall be a 15-inch TFT color touch screen, industrial operator interface.
 - b. The HIM shall have one (1) USB port and one (1) Ethernet port.
 - c. The HIM shall be Allen-Bradley PanelView Plus
 - 4. Terminal Blocks

- a. The terminal blocks used in the BNR control panel shall be as specified in the BNR section and supersedes other terminal block specifications as provided by the Manufacturer.
- b. Power Terminals: Unit construction type with closed back tubular pressure screw connectors, rated 600 volts
- c. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with spring type connectors, rated 300 volts.

F. Operation

1. The HIM shall allow the Operator the ability to modify the following, but not limited to, setpoints and parameters for the operation of the system:
 - a. MANUAL MODE – AERATORS
 - i. VFD speed adjustment
 - ii. DO loop setpoints and limits
 - iii. Aerator adjustment delay
 - b. AUTO MODE – AERATORS
 - i. Aerator power input shall be adjusted to match process oxygen demands using DO concentration as the primary control parameter. The D.O. level shall be monitored at the location shown on the drawings.
 - ii. The DO signal shall be used to pace the VFD in "Auto" operation. In "Manual" operation, the Operator shall be able to control the speed manually by using the HIM.
 - iii. Allow selection of PID or Step Control.
 - iv. Allow input of DO set points and limits.
 - v. Allow selection of DO. Probes to use for control: (one [1] DO probe per aerator or one [1] DO probe for both aerators).
 - vi. Allow selection of shutdown mode for each aerator.
 - vii. Include timers for aerator shutdown to ensure aerators do not shut down for more than an operator set value when not in fault.
 - viii. Include separate DO Alarm set points with timers.
 - ix. Allow disabling individual DO alarms (but not equipment alarms).
 - x. Operators shall be allowed to operate one (1) aerator in MANUAL and one (1) in AUTO and control system shall operate the aerator in AUTO accordingly.
 - xi. Proper velocity shall be maintained while running both aerators in AUTO operation.
 - xii. The DO levels shall have defined limits that shall be user-defined but factory preset on the HIM. The factory set algorithms shall be the responsibility of BNR equipment Manufacturer and shall be specifically designed for the installed system.
 - xiii. The entire system shall be designed to restart after power outage if no alarm conditions are present that would normally shut the unit down.

- xiv. Real time DO level(s).
- xv. Aerator status.
- xvi. Low oil pressure and high motor temperature shall shut down aerators in both MANUAL and AUTO mode. System shall allow for oil pump pressure delay during startup of aerators.
- xvii. The aerator OFF time shall be monitored and an exercise alarm activated when a unit needs to be operated for warranty purposes.
- c. The Control System shall allow sufficiently stable basin DO, and level to meet stated process requirements. The HIM shall provide to the operator the following, but not limited to, monitoring parameters.
 - i. Real time VFD speeds
 - ii. Real time DO levels
 - iii. Aerator status
 - iv. Mixer status
 - v. Effluent Weir Position
 - vi. Real time level
 - vii. HIM shall include 48-hour trend graphs which include DO set points, real time DO, level, aerator speeds, all gate/weir positions

G. Control

- 1. The equipment Manufacturer shall coordinate with the systems integrator to determine which points are provided to the SCADA system via Ethernet. Monitoring points shall be available to the SCADA system via Ethernet. The points shall include:
 - a. Aerator speed reference (Hz).
 - b. Aerator alarm status.
 - c. DO reference.
 - d. DO setpoint.
 - e. DO alarm status.
 - f. Effluent Weir Position Adjustment
 - g. Other points as requested

H. Instrumentation

- 1. Analyzer
 - a. The Analyzer shall be a microprocessor based instrument. Connections between the probe sensor and the controller shall be “plug-and-play” without requiring extensive programming or configuration. The system shall be able to perform automatic calibration of the DO monitoring system.
 - b. The controller shall have wireless downloading capability through an IR port located on the controller unit to download and print real time data, calibration history and current set points in a CSV format.

- c. The controller unit shall allow control of the sensor and interface functions using menu driven software. The interface unit shall have a built-in data logger with the capacity to store data on 15-minute intervals for up to six (6) months. The display for the unit shall be a graphic dot matrix LCD display, 128x64 pixels with LED backlighting. All user settings for the controller shall be retained indefinitely in non-volatile memory (EEPROM)
 - d. The controller unit shall include two (2) analog 4-20mA output signals proportional to DO level and temperature, and shall include two (2) independent PID control functions including high/low phasing, setpoints, dead bands, off delay and on delay.
 - e. The unit shall include three (3) SPDT, user configurable Form 'C' alarm contacts, rated at 100 to 230 volts AC, 5 amp resistive maximum. The unit shall be capable of providing the following alarm conditions: low alarm setpoint, low alarm point dead band, high alarm setpoint, high alarm point dead band, off delay and on delay.
 - f. The controller unit shall be housed in a NEMA 4X enclosure with a corrosion resistant finish. The AC power supply to the unit shall be housed in the interface unit and shall automatically accept input in the range of 100 to 230 volts AC, single phase, 60 Hz. The interface unit shall be supplied with a sun shield. The unit shall be capable of exterior mounting, vertically on the handrail.
 - g. The Controller shall be Hach Model SC4500 Controller as manufactured by the Hach Company.
2. DO Probe:
- a. The DO Probe shall be a continuous reading probe that utilizes luminescent sensor technology.
 - b. The probe material shall be foamed Noryl® and Type 316 stainless steel. All parts of the probe shall be corrosion resistant and fully immersible. The D.O. sensor material shall be polybutyl methacrylate.
 - c. The measurement range of the probe shall be 0.00 to 20.00 mg/L dissolved oxygen and 32.0 to 212.0° F (0.0 to 100.0° C) temperature. The operation of the probe/analyzer shall not be affected by H₂S, pH, metals and salts normally found in domestic wastewater. The probe shall provide for electrolyte-free operation without the requirements of sample conditioning.
 - d. The probe shall not require periodic membrane changing. The sensor cap shall be easily replaceable and cleaning accomplished by periodically wiping the sensor with a clean rag. The accuracy of the sensor shall be ±0.1 mg/L for levels less than 1.0 mg/L, and ±0.2 mg/L for DO levels greater than 1.0 mg/L. The sensitivity of the probe shall be ±0.5% of the span and the repeatability of the probe shall be ±0.5% of the span. The response time of the probe shall be 1 to 60 seconds to 90% of the value upon a step change in DO.
 - e. The DO probe shall be the Hach LDO® Probe for DO and temperature measurement as manufactured by the Hach Company.

I. Probe Mounting:

1. DO Probe

- a. The probe(s) shall be provided with a mounting system capable of being attached to hand railing. The probe(s) shall be attached to an arm that is suspended in the basin. The arm shall be Schedule 80 PVC pipe and fittings and furnished by the Contractor.
- b. The swivel bracket that attaches the arm to the hand railing shall be fabricated of Type 316 stainless steel. All nuts, bolts, washers and other hardware used to mount the pole to the swivel bracket and to mount the bracket to the hand railing, shall be furnished.
- c. The probe mounting bracket shall be constructed to allow for easy calibration or exchange of the Probe without the use of tools.

J. Variable Frequency Drives (VFD)

1. The VFD system shall contain all components required to meet the performance, protection, safety and certification criteria of this specification.
2. The BNR VFD(s) shall be provided by BNR equipment Supplier, using Allen-Bradley PowerFlex 750 series
3. The VFD(s) shall be located in the electrical room in a climate controlled building.
4. The VFD(s) shall allow for internal monitoring and control of specific BNR aeration equipment. These signals shall include but not limited to:
 - a. Oil pressure monitoring
 - b. Motor thermal overload monitoring
5. The VFD(s) shall be 6-pulse.
6. Hardware
 - a. Utilize diode bridge or SCR bridge on the input rectifier.
 - b. Utilize switching logic power supply operating from the DC bus.
 - c. Incorporate phase to phase and phase to ground MOV protection on the AC input line.
 - d. Microprocessor based inverter logic shall be isolated from power circuits.
 - e. Utilize latest generation IGBT inverter section.
 - f. Inverter section shall not require commutation capacitors.
 - g. Ethernet port for direct network cable connections.
 - h. Battery receptacle for lithium battery power to the real time clock.
 - i. Additional DPI port for handheld and remote HIM options.
 - j. Dedicated Digital Input for hardware enable.
 - k. Optional onboard 24 VDC auxiliary control power supply
7. Control Logic
 - a. Ability to operate with motor disconnected.
 - b. Provide a controlled shut down, when properly protected, with no component failure in the event of an output phase to phase or phase to ground short circuit. Provide annunciation of the fault condition.

8. Power Conditioning
 - a. Designed to operate on an AC line which may contain line notching and up to 10% of voltage harmonic distortion.
 - b. An input isolation transformer shall not be required for protection from normal line transients.
9. Current Limit
 - a. Programmable current limit.
 - b. Current limit shall be active for all drive states: accelerating, constant speed and decelerating.
 - c. The drive shall employ PI regulation with an adjustable gain for smooth transition in and out of current limit.
10. Flying Start
 - a. The drive shall be capable of determining the speed and direction of a spinning motor and adjust its output to "pick-up" the motor at the rotating speed.
11. Inputs and Outputs (I/O)
 - a. The I/O option modules shall consist of both analog and digital I/O.
 - b. No jumpers or switches shall be required to configure digital inputs and outputs.
 - c. All digital I/O functions shall be fully programmable.
 - d. The control terminals shall be rated for 115 VAC.
 - e. Inputs shall be optically isolated from the drive control logic.
 - f. The control interface card shall provide input terminals for access to fixed drive functions that include start, stop, external fault, speed, and enable.
12. Ratings
 - a. Voltage
 - i. Capable of accepting nominal plant power of 480 VAC at 60Hz.
 - ii. The supply input voltage tolerance shall be $\pm 10\%$ of nominal line voltage.
 - b. Displacement Power Factor
 - i. Capable of maintaining a minimum true power factor (true power factor=displacement power factor X distortion power factor) of 0.95, lagging, over the entire speed range.
 - c. Efficiency
 - i. A minimum of 96.5% ($\pm 1\%$) at 100% speed and 100% motor load at nominal line voltage.
 - ii. Control power supplies, control circuits, and cooling fans shall be included in all loss calculations.
 - d. Operating ambient temperature range without derating: 0°C to 40°C (32°F to 104°F)
 - e. Operating relative humidity range shall be 5% to 95% non-condensing.
 - f. Operating elevation shall be up to 3,300 feet (~1,000 meters) without derating.

13. The VFD shall be rated at heavy duty loads and shall provide 150% overload capability for up to one (1) minute, and 180% for up to three (3) seconds.
14. Communications
 - a. VFD shall provide an Embedded Ethernet/IP port.
15. Enclosure Door Mounted Human Interface Module (HMI)
 - a. VFD shall provide a HIM with integral display, operating keys and programming keys.
 - b. The HIM shall be rated NEMA/ UL Type 4/12 panel mounting that is connected via cable.
 - c. The display portion shall have the following features:
 - i. The display shall be a seven (7) line by twenty-one (21) character backlit LCD display with graphics capability.
 - ii. The display shall display drive operating conditions, adjustments and fault indications.
 - iii. The display shall be configured to display in three (3) distinct sections.
 - iv. The first section shall be a status display for direction, status, fault / alarm conditions and Auto / Manual mode.
 - v. The second section shall display drive output frequency.
 - vi. The third section shall be configurable as a display for either programming menus / information or as a two-line user display for two (2) additional values utilizing scaled units.
 - vii. The HIM shall provide digital speed control.
 - viii. The keypad shall include programming keys, drive operating keys (Start, Stop, Direction, Jog and Speed Control), and numeric keys for direct entry.
16. Enclosure
 - a. Shall be rated UL Type 12.
 - b. Shall be painted per the Manufacturer's standard.
 - c. Shall provide entry and exit locations for power cables.
 - d. Shall contain a label for UL508.
 - e. The drive system nameplate shall be stamped with SCCR ratings inside the enclosure.
17. Drive Input Disconnect
 - a. VFD shall provide a door interlocked fused disconnect switch
 - b. Operator Handles
 - i. Provide externally operated handles for disconnects.
 - ii. Handles shall be lockable.
18. Control Power Transformer
 - a. Provide a control power transformer mounted and wired inside of the drive system enclosure.

- b. The transformer shall be rated for the VFD power requirements.
- 19. Auxiliary Relays
 - a. Provide relays for Drive Alarm, Drive Fault, Drive Run, and System Status Faults as required.
 - b. The relays shall be Allen-Bradley 700-HC (2 N.O. & 2 N.C.) or equal. The relay contacts shall be rated for 115 VAC/30 VDC, 5.0 amp resistive, 2.5 amp inductive.
- 20. Control Interface
 - a. The control terminals shall be rated for 115 VAC.
 - b. Inputs shall be optically isolated from the drive control logic.
 - c. The control interface card shall provide input terminals for access to fixed drive functions that include start, stop, external fault, speed, and enable.
- 21. Motor Heater Control
 - a. The drive system shall provide the drive control circuitry to energize an existing motor heater whenever the motor is not running.
 - b. The heater control shall be interlocked with the drive and/or bypass and shall be energized whenever the motor is not running.
 - c. The device shall be an Allen-Bradley Bulletin 800T [30mm] NEMA Type 4/13 or equal, mounted on the drive system enclosure door.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Contractor shall provide all labor and materials to install all equipment in accordance with the Manufacturer's recommendation. The Contractor is responsible for obtaining detailed erection drawings.
- B. Contractor shall provide all anchor bolts, hardware, connectors, gaskets and supports required that are not included in the Oxidation Ditch aeration system scope of supply.
- C. Contractor shall provide, at a minimum, the following.
 - 1. Unload and store all equipment on site.
 - 2. Provide and install field wiring, conduits, wire ways, and cable trays.
 - 3. Provide and install all platforms, gratings, handrails, ladders and stairs.
 - 4. Start-up factory services for all equipment not included in the Manufacturer's field service scope of supply. This includes all coordination required, factory service costs including travel and per diem.
 - 5. All start-up chemicals, as required.
 - 6. All lubricants required for all other equipment associated with the Oxidation Ditch aeration system that are not included in the Manufacturer's scope of supply.

3.02 INSTALLATION INSPECTION AND FIELD TESTING

- A. The Manufacturer of the mechanical surface aerators and mixers shall furnish the services of a factory representative who has complete knowledge of proper operating and maintenance to inspect the final installation and supervise a test run of the equipment. The Manufacturer shall furnish two (2) separate trips and four (4) days total on-site service.
- B. The test runs on the mechanical aerators and mixers shall be undertaken with water in the aeration tanks filled up to the high water elevation shown on the Contract Drawings. The Contractor shall be responsible for providing sufficient water, or treated wastewater for filling the tanks for the test runs on the aerators. The test runs on the aerators shall confirm acceptable normal running noise, speed and direction.
- C. After the equipment is installed and aligned, and the Manufacturer's recommendations for initial start-up have been implemented, the aerator shall be run at full speed and full load for a minimum of two (2) hours after the oil temperature has stabilized. The gear reducer housing and shaft seals shall be checked for leakage of lubricant. Any leaks shall be corrected and the temperature rise of the lubricant in the oil sump of the gear reducer shall not exceed 100°F above ambient temperature.
- D. In the event of improper installation, the Contractor shall be responsible for supervising the correction of the work and subsequent test runs until the defects are corrected.

3.03 PAINTING

- A. Unless otherwise noted, all ungalvanized fabricated iron and steel surfaces shall receive a shop-cleaned surface preparation equivalent to SSPC-SP-10 immediately prior to shop-priming. Shop-priming shall consist of one (1) coat of Tnemec 161-1211 primer or approved equal to 3.0 to 5.0 mils DFT. Touch up and finish painting shall not be the responsibility of the equipment Manufacturer.
- B. The motors and gear reducers shall receive a minimum shop-cleaned surface preparation equivalent to SSPC-SP-1 immediately prior to shop-priming and finish coating. Shop-priming and finish painting shall consist of a coating that is compatible with a high quality finish coating that is specifically resistant to chemical, solvent, salt water, and acid environmental conditions. Touch-up painting shall not be the responsibility of the equipment Manufacturer.

END OF SECTION

SECTION 46 61 41
DISC CLOTH FILTERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes: Two (2) factory-built, painted steel, package Disc Cloth Media Filters, factory tested and ready for operation.
- B. All motors, pumps, and bearings shall be designed for continuous duty and long operating life in a high humidity atmosphere. All motors and pumps shall be 460 volt, 60 hertz, 3 phase.
- C. Purchased components such as gear reducers, pumps, motors, valves, and actuators shall be provided with standard recommended Manufacturer's paint, unless otherwise specified within this section.
- D. Related Sections:
 - 1. Section 03 30 00 Cast-in-Place Concrete
 - 2. Section 03 60 00 Grouting
 - 3. Section 05 50 00 Metal Fabrications
 - 4. Section 09 90 00 Painting
 - 5. Electrical Division 26
- E. The Disc Cloth Filters Equipment shall be pre-selected as stated in the Subsection entitled "Manufacturers Equipment" within Section 01 20 00 Price and Payment Procedures of these Specifications.

1.02 SYSTEM DESCRIPTION

- A. Factory-built, painted steel, package disc cloth media filter.
- B. System components include tank, center tube with cloth media disks, valves, motors, pumps, bearings, drive assembly, backwash/sludge discharge assembly, pressure transducer, and electrical controls with internal components as specified.
- C. Contractor to provide stairs and access platforms as indicated on the Contract Drawings.

1.03 PERFORMANCE REQUIREMENTS

- A. Influent Criteria:
 - 1. Average Daily Flow: 1.0 MGD
 - 2. Peak Daily flow: 1.5 MGD
 - 3. Average TSS: 200 mg/L
 - 4. Peak TSS: 200 mg/L
 - 5. P: 8 mg/L
- B. Performance Criteria: Produce effluent with the following maximum limits:
 - 1. TSS: 5 mg/L
 - 2. P: 0.33 mg/L

- C. Design Criteria:
 - 1. Provide filter capable of filtering effluent from an activated sludge process with secondary clarifiers with an SRT of 17 days.

1.04 SUBMITTALS

- A. Section 01 33 00 Submittal Procedures: Requirements for submittals.
- B. Shop Drawings:
 - 1. Submit certified shop and installation drawings showing materials, details of construction, dimensions and connections to work of other sections.
 - 2. Show complete information concerning fabrication, installation, anchoring, fasteners and other details.
- C. Product Data:
 - 1. Submit Manufacturer's product data for system materials and component equipment.
- D. Manufacturer's Installation Instructions: Submit detail instructions on installation requirements including storage and handling procedures, anchoring, and layout.
- E. Manufacturer's Certificate:
 - 1. Certify Products meet or exceed specified requirements.
 - 2. Certify installation is completed in accordance with Manufacturer's instructions and that package disc filter is ready for startup, testing, and operation.
 - 3. Submit Manufacturer's affidavit certifying filter has been designed to resist loading and attest to structural adequacy; calculations are not to be submitted.
- F. Manufacturer's Field Reports: Submit reports of Manufacturer's inspections and instructions issued.

1.05 CLOSEOUT SUBMITTALS

- A. Section 01 70 00 Execution and Closeout Requirements: Requirements for Submittals.
- B. Project Record Documents: Record actual locations and final orientation of equipment and accessories.
- C. Operation and Maintenance Data: Submit equipment operation and maintenance manuals.
 - 1. Include periodic maintenance recommendations.
 - 2. Include list of equipment, accessories and tools needed to maintain and calibrate equipment.

1.06 QUALITY ASSURANCE

- A. A single Manufacturer shall furnish all the equipment specified under this section and as shown on the Contract Drawings.
- B. Contractor shall furnish all labor, materials, equipment, and incidentals required for installation of the disc cloth filter as shown on the Contract Drawings and as specified in this Specification.

- C. Contractor shall provide freeze protection.
- D. Contractor shall provide access stairs and platform as shown on the Drawings.
 - 1. Access platforms: Self-supporting and not attached to the filter tank.

1.07 QUALIFICATIONS

- A. Manufacturer: Experienced in the design and manufacture of cloth media filters for a minimum of ten (10) years and be able to demonstrate a minimum of fifty (50) installations within the United States in municipal wastewater applications with cloth media.

1.08 PRE-INSTALLATION MEETINGS

- A. Section 01 30 00 Administrative Requirements: Pre-Installation Meeting.

1.09 COORDINATION

- A. Section 01 30 00 Administrative Requirements: Requirements for Coordination.
- B. Contractor to coordinate installation and start-up with Owner and Manufacturer.

1.10 WARRANTY

- A. Section 01 70 00 Execution and Closeout Requirements: Requirements for Warranties.
- B. The Manufacturer shall provide a written warranty for a period of one (1) year from the date the goods are put into service.

1.11 MAINTENANCE MATERIALS

- A. Section 01 70 00 Execution and Closeout Requirements: Requirements for Maintenance Materials.
- B. Furnish one complete set of Manufacturer's recommended spare parts including:
 - 1. (2) Frame and cloth assemblies.
 - 2. (1) Backwash/Sludge valve and actuator.
 - 3. (1) Viton V-ring effluent port\centertube seal
 - 4. (1) Drive chain
- C. Furnish special tools required for equipment maintenance.

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. Aqua-Aerobics Systems, Inc. Model ADFSP-54x8/4E-PC
- B. Pre-qualified engineer-approved equal.
- C. Pre-qualified engineer-approved equal manufacturers or suppliers wishing to be considered for this project shall submit to the Engineer at least two (2) weeks prior to Bid Date a full

qualification package detailing full compliance with this specification. Manufacturers that do not meet the performance, experience, and quality requirements of this project shall not be pre-approved. Any alternative Manufacturers gaining approval by the Engineer shall be identified via Addendum prior to the Bid Date.

2.02 DISK CLOTH MEDIA FILTER

- A. Tank:
 - 1. Painted steel tank with fixed straight edge influent weir, minimum wall thickness of 10 gauge, tank drain with manually operated brass ball valve.
 - 2. Valve provided loose for installation by the Contractor.
 - 3. Tank Interior: Furnished with near white sandblast (SSPCSP10), painted with Tnemec N69 polyamide epoxy (color "safety blue") two (2) coats 4 to 6 mils each for 8 to 12 mils DFT.
 - 4. Tank Exterior: Commercial sandblast (SSPC-SP6), painted Tnemec N69 polyamide epoxy (color "safety blue") two (2) coats 3 to 4 mils each, one (1) coat of Tnemec 175 Endura shield 2 to 3 mils for 8 to 11 mils DFT.
- B. Drive Assembly: Adjustable drive assembly provided with gearbox, drive sprocket, drive chain and Type 304 stainless steel chain guard.
 - 1. Gearbox: Parallel in-line helical type, AGMA Class 1, 0.75 HP drive motor rated for 460 volt, 3 phase, 60 Hz.
 - 2. Gear Reducer: Nord.
 - 3. Drive motor: Weg, Baldor or Nord.
 - 4. Drive sprocket: Nylon.
 - 5. Chain: Acetal with Type 304 stainless steel link pins.
- C. Center Tube Installation:
 - 1. Minimum 3/16 inch Type 304 stainless steel center tube weldment, driven sprocket, wheel assemblies, Type 304 stainless steel disk segment rods, and frame and cloth assemblies.
 - 2. Center tube to include a Viton V-Ring effluent port seal.
 - 3. Driven sprocket: Multi segment made of UHMW polyethylene.
 - 4. Fasteners: Stainless steel.
- D. Filter Cloth Assemblies:
 - 1. Each tank shall include four cloth disk assemblies. Each cloth disk assembly shall be comprised of six (6) individual segments, each consisting of a cloth media sock supported by an injection molded polypropylene co-polymer frame with corrosion resistant assembly hardware.
 - 2. Cloth Assembly: Constructed such that each segment is easily removable, without special tools, to allow for removal and replacement of the cloth at the point of installation.
- E. Cloth Media: Fiber pile, nominal filtration rating of 5 microns.
 - 1. Effective submerged filtration area per unit: 322.8 square feet minimum.
 - 2. Effective submerged filtration area per cloth disk assembly: 53.8 square feet minimum.
- F. Filtered effluent shall be used for backwashing.

2.03 BACKWASH AND SLUDGE DISCHARGE ASSEMBLY

- A. The backwash function shall incorporate a pump that draws filter effluent through the cloth as the media rotates past the fixed backwash shoe, thereby removing accumulated solids from the cloth surface.
- B. Because of the frequency of the backwash and misting associated with spray systems, designs that utilize high pressure spray or a moving vacuum head as the sole means of solids removal will not be acceptable.
- C. Each backwash/sludge discharge assembly:
 - 1. Include one (1) backwash pump, valves and gauges.
 - 2. Include backwash valves, two (2) 3-inch recirculation ball valve, 3-inch manually-operated gate valve for flow control, vacuum gauge, vacuum transducer, and a pressure gauge in the external piping.
 - 3. Include Type 304 stainless steel backwash shoe supports with end springs, UHMW backwash shoes, PVC reinforced flexible hose, and backwash manifold with Type 304 stainless steel hose clamps and a PVC sludge collection manifold.
 - 4. The backwash shoe shall be in direct contact with the cloth to ensure effective media cleaning.
- D. Backwash Pump, Each Filter:
 - 1. Gorman Rupp model 12B20-B, externally mounted centrifugal pump with case heater with a 2 HP, 460 volt, 3 phase, 60 Hz motor, Weg or approved equal.
 - 2. Rated for 130 gpm at 23 feet TDH.
 - 3. Backwash time interval elapses:
 - a. Operator shall have the ability to specify through operator interface.
 - b. Enabled by tank water level, timer or manual initiation.
 - 4. The backwash water shall be pressurized by the filter's backwash pump for discharging from the filter system.
 - 5. Pump manually operated threaded gate valve: Class 125 bronze with screw in bonnet, non-rising stem, and solid wedge; conform to MSS SP-80; Nibco or approved equal.
 - 6. The 3-inch threaded ball valves shall be a two-piece, full port, with a brass body. Valves shall be Nibco or approved equal.
 - 7. Vacuum gauge(s): Minimum 2.5 inch dial with all stainless steel welded construction, 0-30-inch vacuum range, liquid filled, 1/4-inch back or bottom connection, Type 316 stainless steel bourbon tube and tip material, and bronze socket material, Ashcroft or approved equal.
- E. Vacuum transducer: The vacuum transmitter shall have stainless steel wetted parts and provide a 4-20 mA signal over a range of -30 to 0 inHg. Transmitter shall be an IFM Effector PX series or approved equal.
- F. Pressure gauge(s): 2.5-inch dial with a black painted steel case, 0 to 15 psi, heat-resistant polycarbonate window, 1/4-inch lower connection, "C" shaped bronze bourbon tube, and brass socket material, Ashcroft or approved equal.
- G. Filtering shall not be interrupted during normal backwashing and sludge discharge.
- H. Backwash Valve: Two (2) 2-inch, three-piece, grooved end, ASTM A351 Grade CF8M stainless steel body, Type 316 stainless steel ball and stem, fullport, painted cast iron

Victaulic couplings, with a 115 volt, 1 phase, 60 cycle open / close service electric actuator. combination: TCI /RCI (RCI, a division of Rotork) or Nibco.

- I. Sludge Valve: One (1) 2-inch sludge valve, three-piece, grooved end, ASTM A351 Grade CF8M stainless steel body, Type 316 stainless steel ball and stem, fullport, painted cast iron Victaulic couplings, with a 115 volt, 1 phase, 60 Hz open / close service electric actuator. TCI / RCI (RCI, a division of Rotork), or Nibco.
- J. Sludge removal system: Perforated manifold, mounted on the floor of the filter tank, designed to siphon settled sludge for discharge through the backwash pump. Automatic operation with user adjustable intervals and duration through the operator interface.

2.04 INFLUENT VALVE

- A. Each filter shall include one (1) influent valve, 12-inch lugged style influent butterfly valve, ductile iron body, aluminum bronze disk, stainless steel shaft and EPDM seat. Nibco or approved equal.
- B. Include gear operator and hand wheel.

2.05 PRESSURE TRANSDUCER

- A. The pressure transducer shall have stainless steel wetted parts and provide a 4-20 mA signal over a range of 0 to 5 psi. Unit shall monitor the water level of each filter tank. Transmitter shall be flush mounted to the tank wall. Transmitter shall be an IFM Effector PX series or approved equal.

2.06 HIGH LEVEL FLOAT SWITCH

- A. A float switch shall be furnished to indicate emerging overflow level. The float switch shall be Anchor Scientific Model GSI 40NONC or approved equal. The float shall contain a non-mercury switch, chemical resistant polypropylene casing hermetically sealed and a PVC #18 AWG three conductor cable. Switch rating shall be minimum 4.5 amps non-inductive at 120 VAC.

2.07 CONTROL SYSTEM

- A. Controls: Furnished fully assembled, wired and pre-programmed in a NEMA rated UL certified control enclosure.
- B. Control Panel Wiring and Assembly:
 - 1. Enclosures: Custom assembled, wired in an UL certified cabinet shop.
 - 2. Control Panel Wire: 16 AWG multi-strand machine tool wire minimum, with MTW insulation.
 - 3. Wires shall be clearly marked with identification number consistent with wiring schematic drawing.
 - 4. Wiring inside the Control Panel: Run in PVC wiring duct rated for continuous temperatures up to 122°F. Devices mounted in enclosure door shall have wires run in spiral wrap to avoid pinch points when opening and closing the door.
 - 5. Control components shall be mounted with stainless steel hardware and labeled clearly with a plastic identification nametag.

- C. Conduit:
 - 1. Protect wiring of pre-assembled and mounted external electrical components to control panels or junction boxes with rigid PVC nonmetallic schedule 40 conduit and fittings.
 - 2. Size conduit for adequate spare capacity.
 - 3. Conduit unions and fittings shall be solvent cemented in accordance with instructions from the Manufacturer.
 - 4. All conduit shall be supported at 3-foot intervals.
 - 5. Conduit shall be impact, corrosion and sunlight resistant and be rated for a maximum ambient temperature of 122°F, rated for use with 90°C conductors and shall be UL Listed for exposed or outdoor usage.
 - 6. Vendor shall be Carlon or equal.
- D. Control Panels: UL Certified, tested by Manufacturer's electrical engineering prior to releasing for shipment, with all applicable signed testing documentation placed in the drawing pocket of the enclosure.
- E. Control Enclosure:
 - 1. Control enclosure shall be mounted to the unit.
 - 2. Automatic controls shall be provided in a UL listed, NEMA type 4X Type 304 stainless steel (14 gauge) wall mounted enclosure that provides insulation and protection for electrical controls and components from highly corrosive environments indoors and outdoors.
 - 3. Enclosure shall include a seamless foam-in-place gasket to assure watertight and dust-tight seal.
 - 4. Provide internal 3-point latch and Type 316 stainless steel padlocking power glide handle.
 - 5. Enclosures shall be unpainted, with a smooth brushed finish.
 - 6. Enclosure Sub-panel: Painted white mild steel (10 gauge) and mounted with collar studs.
 - 7. Hoffman or approved equal.
 - 8. Include a 10 gauge Type 304 stainless steel sun shield that hangs over the front of the panel a minimum of 10 inches.
 - 9. An electric heater shall be provided inside the control enclosure to protect sensitive mechanical and electrical components from the harmful effects of condensation, corrosion and low temperatures. The heater is a thermostatically controlled, fan-driven unit. The heater shall be manufactured by Hoffman or approved equal.
- F. Main Disconnect Circuit Breaker
 - 1. UL listed, automatic molded case 3-pole disconnect breaker shall be provided in the control enclosure(s) to provide a means to manually open a circuit and automatically open a circuit under overload or short circuit conditions
 - 2. The disconnect shall have a door mounted operating mechanism with trip indication.
 - 3. Power distribution connectors shall be mounted integrally to the circuit breaker for multiple load connections.
 - 4. Integral connectors shall be provided.
 - 5. The disconnect circuit breaker shall be Square D/FAL, KAL, LAL, MAL, or approved equal.
- G. Power Distribution fusing:
 - 1. Properly rated fuses and fuse blocks shall be provided for primary and secondary protection of the transformer. Each fuse shall be equipped with a thermoplastic cover to protect against accidental contact.

2. Clip style fuse block shall be rated up to 600 VAC and 100 amps, dual element, time delay fuses shall be rated up to 600 VAC. Fuse blocks and fuses shall be UL listed. Fuses shall be Littelfuse FLSR, FLNR or approved equal. Fuse blocks shall be Marathon or approved equal.
- H. Transformer:
1. A step-down multi-tap transformer shall be supplied when there is a necessity to reduce incoming 3-phase power to 120 VAC single phase. The transformer power wire connections (incoming and outgoing) shall be protected with a cover to protect against accidental contact. Primary and secondary fuse protection shall be provided. Transformer shall be UL listed and of continuous wound construction with vacuum impregnated with nonhygroscopic thermosetting varnish. Transformer shall be SquareD 9070T or approved equal.
- I. Branch and Supplementary Protection:
1. Circuit Breakers: Protected with a single-pole, C-Curve rated circuit breaker. Circuit breakers shall be rated for 240 VAC maximum, 50/60 Hz and UL 489 listed. Merlin Gerin Multi 9 or approved equal.
 2. Fuses: Properly rated fuses and fuse holders shall be provided for protection of individual control devices (discrete and analog signals) mounted outside of the enclosure. Each fuse shall be housed in a hinged type fuse block to protect against contact with the fuse. Fuses shall be rated up to 250 VAC and be Littelfuse or approved equal. Fuse holders shall be rated to 600 VAC and 30 Amps and be Allen-Bradley 1492 or approved equal.
- J. Motor Starters: UL listed Self-Protected Combination Motor Controller shall be provided for all motors. The starter shall combine all the functions of a disconnect, circuit breaker, contactor and overload relay in a coordinated motor controller. The starter shall be an IEC rated starter, provide a minimum 42 kA interrupt rating, a padlockable isolation knob and a 600 VAC insulation rating. Contactor coil voltage shall be rated for 120 VAC. Overload protection shall be class 10 and be ambient compensated. Schneider Electric TESYS U or approved equal.
- K. Terminal Blocks: Standard feed-through screw terminal blocks, DIN rail mounted, shall be supplied for all point to point wiring connections. Terminals numbered per the wiring schematic with printed markers. Terminals shall carry a 600V AC/DC voltage rating and insulation temperature rating of -40°F to 195°F. Allen-Bradley 1492-J4 (35A max) and 1492-J16 (85A max) or approved equal.
- L. Control Relays: UL listed control relays for general control purposes shall be supplied with a pilot light to indicate when the coil is in an energized state. The relay socket shall be panel or DIN rail mounted inside the enclosure. The relays shall provide the following ratings: 120 VAC coil, 10A contact rating (thermal), 250 VAC insulation rating, 6 million mechanical life cycles and an operating temperature of -22°F to 131°F. Allen-Bradley 700-HK or approved equal.
- M. Ground Fault Duplex Receptacle: UL listed ground fault circuit interrupter (GFCI) duplex receptacle shall be provided within the panel for instrument (e.g. programming terminal, modem, etc.) use only. The receptacle shall be protected with a 5 Amp circuit breaker. The receptacle shall carry a 20A / 125VAC rating. The electro-mechanical circuit interrupter shall be double-pole and trip free (GFCI protection and shall not be overridden by holding reset

button). Built-in transient suppression shall protect GFCI's internal circuitry from voltage transients. Receptacle shall be Hubbell DRUBGFI20 or approved equal.

- N. High Frequency Noise Filter: A UL listed active tracking filter shall be provided to protect the PLC and HMI power feeds from high-frequency noise and low-energy transients. It shall be designed for a single phase input voltage of 120/240VAC operating at 47 to 63 Hz. The unit shall reduce normal mode transients to plus or minus 2 volts, provide surge capacity of 45,000 amps and protect in all modes (Line to neutral, line to ground and neutral to ground). The noise filter shall be an Islatrol IC+ or approved equal.
- O. 24 Volt DC Power Supply: A UL listed, industrial grade, compact power supply shall be supplied to provide 24 VDC power to such rated components. The power supply shall be DIN rail mounted and functional with 120 or 230 VAC (single and three phase) incoming control power. The power supply shall have a green LED which shall be illuminated when output voltage is "OK". The unit shall provide for internally fused input connections, a nominal output current of 2.1A and operate in a temperature range between 14°F and 158°F. The power supply shall be an Allen-Bradley 1606 or approved equal.
- P. Operator Devices: 30.5 mm style, NEMA 4X rated, oil and water tight with finger safe guards located on the contact blocks to prevent accidental contact with wire connections.
 - 1. UL listed operator devices (pushbutton and selector switches) shall be mounted through the control enclosure door for manual operation of the filter system.
 - 2. Transformer type pilot lights and illuminated pushbuttons shall be provided for indication of an operation status.
 - 3. Color coding shall be applied as required.
 - 4. Operator device function shall be identified with an engraved white gravoply nameplate with black letters.
 - 5. Operator devices shall be Allen-Bradley 800H.
- Q. Programmable Logic Controller (PLC):
 - 1. Automatic operation of the Filter shall be controlled through a Allen Bradley MicroLogix 1400 programmable logic controller (PLC) mounted inside the main control panel. The PLC components shall consist of a base unit, expansion I/O modules, and memory module. All input and output points supplied (including unused) shall be wired to terminal blocks. The PLC user memory shall consist of a minimum of 20K words of program and data. All PLC hardware shall be UL listed and operate at an ambient temperature of -4° to 140° F (-20° to 60° C).
 - 2. The base unit shall house embedded inputs, outputs, power supply, and communication (Ethernet, RS-232, RS-485) ports. The base unit shall also provide the interface to expansion I/O when required by an application.
 - 3. The power supply input range shall be 100 to 240V AC at 47 to 63 Hz with a maximum power consumption of 100 VA.
 - 4. The embedded discrete inputs shall be rated for 120V AC and the discrete (relay) outputs shall be rated for 265V AC/125V DC. Embedded analog I/O shall be voltage (± 10 V) inputs and outputs. Each I/O point shall have LED status indication.
 - 5. The base unit shall have one (1) RS-232-C serial port, one (1) RS-485 serial port, and one (1) RJ-45 port which supports 10/100 Mbps Ethernet/IP. These ports shall be capable of local and remote programming, troubleshooting, and data manipulation.
 - 6. The PLC base unit shall be an Allen Bradley 1766-L32AWAA or approved equal.

7. The expansion digital input module shall have an operating voltage of 79 to 132V AC at 47 to 63 Hz. The module shall have an LED status indication of each point. The digital expansion input module shall be an Allen Bradley 1762-IA8 or approved equal.
 8. The controller shall be shipped with a memory module for user program and data backup. The memory module shall be an Allen Bradley 1766-MM1 or approved equal.
- R. Human Machine Interface (HMI):
1. Equip control system with UL listed operator interface that provides control display screens Used by operator to monitor and control filter status, set point and alarm information.
 2. Operator interface shall be 6.5 inches diagonal, color touch screen display with Ethernet and serial communications, liquid crystal display (LCD), color active matrix thin-film transistor (TFT) with 640 x 480 pixel resolution, and 18-bit color graphics. The rated operating temperature shall be 32 degrees to 131 degrees F.
 3. The operator interface shall be an Allen-Bradley PanelView Plus 700.
 4. Interface shall provide operator access to adjust backwash interval, backwash duration, sludge waste interval, sludge waste duration, and number of backwashes between sludge wasting.
 5. Interface Screen shall display the following at a minimum:
 - a. Water level in the filter.
 - b. Time since last backwash.
 - c. Time since last sludge withdrawal.
 - d. Elapsed time on the drive motor.
 - e. Elapsed time on the backwash pump.
 - f. Total backwash time and cycle.
 - g. Total sludge withdrawal time and cycles.
 6. Interface shall display alarm history:
 - a. Display time, date, and description of most recent twenty-five (25) alarms.
 - b. Display current alarms, including the date, time and description of the alarm.
 7. Interface shall display the time between backwashes for the most recent forty (40) backwashes as a diagnostic aid to the operator.
- S. Operator Interface Sunshield:
1. Sunshield: Constructed of Type 304 stainless steel, mounted over the operator interface to provide protection and visibility of operator screens in outdoor applications.

PART 3 EXECUTION

3.01 INSPECTION

- A. Contractor to verify layout and orientation of treatment unit, accessories, and piping connections.
- B. Contractor to inspect all equipment prior to installation. Contractor to repair or replace damaged items as directed by the Manufacturer, at no additional cost to the Owner.

3.02 INSTALLATION

- A. Contractor shall install the disc cloth media filter according to the Manufacturer's installation instructions and Contract Drawings.

- B. The drawings and specifications are based on Aqua-Aerobic Systems, Inc AquaDisk filter equipment. Any costs resulting from changes required for other approved filter equipment shall be borne by the Contractor.

3.03 EQUIPMENT PERFORMANCE TESTING

- A. Test in accordance with Manufacturer's instructions and under the supervision of the Manufacturer's representative.
- B. Contractor shall notify the Owner and Engineer at least seven (7) days before testing and inspection is conducted to enable the Owner and Engineer to witness the tests.
- C. Contractor shall furnish all labor, materials, power, water, equipment, instrumentation, and any other equipment and services necessary for conducting the field performance testing.
- D. Contractor shall submit to Engineer complete test reports for all tests, describing units tested, type of test, test setup, procedures, instrumentation, test flow rates, and all other data and results as required to demonstrate that all items tested meet specified requirements.
- E. The by-passing of flow during any of the test conditions is not permitted. If by-passing occurs during testing, the test must be restarted.
- F. In the event the performance testing is deemed unsuccessful, the Manufacturer shall have the option to modify the filter(s) as necessary to achieve the guaranteed performance. The maximum liability to the Manufacturer for the modification or supply of additional equipment shall be limited to 100% of the purchase price of the equipment supplied.

3.04 EQUIPMENT START UP

- A. Contractor shall have Manufacturer's representative check and verify that installation of the filter is in accordance with the Contract Drawings and Manufacturer's installation instructions.
- B. The Contractor shall start-up and test in accordance with these Specifications.
- C. The Contractor shall have Manufacturer's representative instruct plant personnel on operation and maintenance of filters.

3.05 MANUFACTURER'S FIELD SERVICES

- A. Section 01 40 00 - Quality Requirements: Requirements for Manufacturer's Field Services.
- B. The equipment Manufacturer shall furnish the services of a factory trained representative for one (1) trip and three (3) eight (8) hour days at the jobsite to:
 - 1. Inspect the Contractor's equipment installation.
 - 2. Supervise the initial operation of the equipment.
 - 3. Instruct the Operator in proper operation and maintenance.
 - 4. Provide process assistance.
- C. The equipment Manufacturer shall furnish the services of a factory trained representative for one (1) trip and three (3) eight (8) hour days at the jobsite for performance testing.

3.06 CERTIFICATION

- A. The Manufacturer representative shall prepare written certifications stating the equipment is installed properly, is operating within the design parameters, and will be warranted as required by the Specifications.

END OF SECTION

SECTION 46 66 00
ULTRAVIOLET EQUIPMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Manufacturer shall furnish a complete in-line pipe flanged, low pressure high intensity (LPHO) Ultraviolet (UV) Non-Contact disinfection system to provide required disinfection of plant effluent waters prior to ultimate plant discharge.
- B. UV systems that require lamps with input power greater than 145 watts shall not be considered. Amalgam lamps shall not be considered, system with quartz sleeve surrounded lamps shall not be considered.
- C. The equipment shall essentially be automatic in operation, with no automated cleaning apparatus. Separate cleaning apparatuses, integrated wiper mechanisms, quartz sleeves, O-rings, or lifting cranes shall not be required as per the non-contact UV disinfections system.
- D. The system shall be complete with power enclosures, power distribution and system controls as shown on the Contract Drawings and specified herein.

1.02 SUPPLIER

- A. Acceptable Manufacturers:
 - 1. Enaqua Non-Contact UV System
 - 2. Aquionics UV System
- B. Being named an "Acceptable Manufacturer" does not relieve said manufacturer from meeting all requirements in this specification.

1.03 RELATED WORK

- A. Division 03 Concrete
- B. Section 40 05 58 Slide Gates
- C. Electrical work, except as specified herein is included in Division 26.

1.04 SUBMITTALS

- A. Submit shop drawings in accordance with the Section 01 33 00 Submittal Procedures. Copies of all materials required to establish compliance with this Section. Submittals shall include at least the following.
 - 1. Certified shop and erection drawings showing all details of construction, dimensions and anchor bolt locations.
 - 2. Descriptive literature, bulletins, and/or catalogs of the equipment.
 - 3. The total operational weight of the equipment including the weight of the single largest

component.

4. Complete bill of materials of all equipment.
 5. List of the Manufacturer's recommended spare parts.
 6. Complete control panel component and wiring schematics.
 7. Hydraulic calculations demonstrating compliance with the required hydraulic characteristics.
- B. Test Reports to be Submitted the Engineer and Owner:
1. Description of test procedures and equipment.
 2. Copies of all test results, as specified in Parts 2 and 3 of this Specification.
- C. Complete operating and maintenance instructions shall be submitted in accordance with the requirements of Section 01 70 00 Execution and Closeout Requirements of these Specifications.

1.05 REFERENCE STANDARDS

- A. Design, manufacturing and assembly of elements of the products specified herein shall be in accordance with the standards of the below listed organizations.
1. American National Standards Institute (ANSI)
 2. Underwriters Laboratory (UL)
 3. National Electric Code (NEC)
 4. American Society for Testing and Materials (ASTM)
 5. American Iron and Steel Institute (AISI)
 6. Factory Mutual (FM)
- B. Where reference is made to a standard of one of the above, or other organizations, the version of the standard in effect at the time of Bid Opening shall apply.

1.06 QUALITY ASSURANCE

- A. A single Manufacturer shall furnish all equipment specified within this Specification manufactured by a competent organization that is fully experienced, reputable and qualified in the manufacture of the equipment to be furnished. The equipment shall be designed, constructed and installed in accordance with best practices and methods, and shall operate satisfactorily when installed.
- B. All equipment as specified within this Section shall be standard products from Manufacturers who have a successful record of manufacturing and servicing the equipment and systems specified herein for a minimum of five (5) years.
- C. These Specifications are intended to give a general description of what is required, but do not cover all details which may vary in accordance with the exact requirements of the equipment as offered. These Specifications are intended to cover the furnishing, delivery, installation, field testing and field calibration of all materials and apparatus as required. Any additional

equipment necessary for the proper operation of the proposed installation not specifically mentioned in these Specifications or shown on the Contract Drawings shall be furnished and installed at no change in Contract Price or Time.

1.07 DELIVERY STORAGE AND HANDLING

- A. Provide in accordance with the Manufacturer's recommendations and with Section 01 60 00.
- B. All equipment and parts shall be properly protected so that no damage or deterioration occurs during shipment or during a prolonged delay from the time of shipment until installation is completed and the unit and equipment are ready for operation. The Contractor shall store equipment in accordance with the Manufacturer's instructions.

1.08 WARRANTY

- A. The equipment furnished (excluding lamps, ballasts) shall be warranted to be free of defects in material and workmanship, including damages that may be incurred during shipping for the lessor of a period of 12 months from the date of substantial completion of the installed UV system or 18 months from the date of receipt of all equipment supplied by the Contractor and received in good condition by the Owner.
 - 1. UV LAMPS: UV lamps shall be warranted for a minimum of 12,000 hours operating time under the conditions specified herein prorated after 9,000 hours. In the event of premature UV lamp failure, the UV system supplier shall offer the following:
 - a. Lamp failure before 9,000 hours – send a replacement lamp free of charge
 - b. Lamp failure after 9,000 hours – issue a credit proportional to the hours not used.
 - 2. BALLASTS: Electronic ballasts are fully warranted for three (3) years, extended to five (5) years with first purchase of (1:1) replacement lamps from the manufacturer's lamps within three (3) years of installation.

1.09 PERFORMANCE AND DISINFECTION GUARANTEE

- A. The manufacturer shall guarantee that the proposed UV disinfection system shall produce an effluent that meets or exceeds the requirements of this specification. The effluent quality exiting the UV system must be equal to or better than the specification requirements. The guarantee shall be applicable for a duration of twenty (20) years from the date of startup as long as the wastewater flow and quality remains in the range(s) specified in Subsection 2.01.A Design Criteria.

PART 2 PRODUCTS

2.01 GENERAL

A. Design Criteria

- 1. The equipment to be supplied and installed shall disinfect an effluent with characteristics as listed in the Table below:

Minimum Flow Rate	1.15/799	MGD/GPM
Average Daily Flow Rate	1.5/1,042	MGD/ GPM

(ADF)		
Peak Design Flow Rate (PDF)	1.75/1,215	MGD/ GPM
Open Channel / In Line / Closed	In Line	
UV Transmittance	65.0	% UVT (Minimum)
Total Suspended Solids*	<20.0	mg/L (30 day average)
BOD*	<20.0	mg/L (30 day average)
Target Pathogen	E. Coli	
Influent Maximum*	200,000	CFU /100 mL
Permit Criteria	126.0 235.0	CFU /100 mL Monthly GEOMEAN CFU /100 mL Weekly Average
UV Dose (Calculated)	30.0	(mJ/cm ² ; mW.s /cm ²) Minimum
Plant Process	Oxidation Ditch, secondary clarification with Cloth/Synthetic Media Disc Filtration prior to UV disinfection	
Mean Particle Size*	<10.0	Microns
Total Iron*	<0.3	mg/L
Turbidity*	2	NTU
Equipment Redundancy	100% redundancy of banks. One (1) UV reactor with two (2) banks, each rated for 100% of the Peak Design Flow Rate	

*Note: Industry standard values used

B. Effluent Standards to be Achieved

1. The UV reactor shall be designed to deliver a minimum UV dose of 30.0 mJ/cm² at Peak Design Flow, after application of an End of Lamp Life (EOLL) factor of 87%, and Fouling Factor of 89%.and shall produce an effluent as follows.
 - a. Effluent Geometric Mean (CFU): 126.0 CFU/100 mL Fecal Coliform
 - b. Single sample maximum (CFU): 235.0 CFU/100 mL Fecal Coliform
2. Effluent standards based on influent characteristics in accordance within Subsection 1.3.A.
3. Effluent indicator organism quantities based on two single day grab samples and as a 30-day Geometric Mean. Grab samples shall be taken in accordance with the Microbiology Sampling Techniques found in Standard Methods for the Examination of Water and Wastewater, 19th Ed.

C. Head Loss

1. Head loss through the reactor shall be as follows.
 - a. Peak Design Flow: < 7.0 inches (flange to flange head loss through UV reactor at 1.75 MGD)

D. Operating Conditions:

1. Outdoor installations shall require a cover for protection against the elements. The cover of the UV unit shall be supplied by the Contractor.
2. The UV system shall be designed to operate at a maximum pressure of 20 psi. Pumped flow through the UV unit shall require a pressure relief valve for protection against over-pressurization/surges and appurtenances for air/vacuum release. The valve(s) to be installed shall be sized by the Manufacturer, reviewed by the Engineer and supplied and

installed by the Contractor.

3. The location and placement of the valves shall be per the Contract Drawings and the Engineer's direction.

2.02 MATERIALS

A. The UV system shall consist of the following components:

1. Reactor Model No: D2t.06042
 - a. Number of reactors: 1
2. Each reactor shall consist of the following:
 - a. Number of Banks per Reactor 2
 - b. Number of AFP Tubes/Bank 24
 - c. Number of Lamp Racks per bank.....5
 - d. Number of Lamps per Lamp Rack 8
 - e. Total number of lamps per bank.....40
 - f. Total number of ballasts per bank 40
 - g. Total number of lamps per reactor 80
3. The UV system shall include the following controls/monitoring:
 - a. Radar Level Sensor 1
 - b. UV Intensity Sensor: 2 (one per UV bank)
 - i. UV intensity sensor
 - c. EDC GEN 2 (Ensure Dosing Controller): 1 (one per reactor)
 - d. HMI Panel: 1
 - e. Power Disconnect Panels: 2 (one per UV bank)
4. Spare parts consisting of the following:
 - a. UV Lamps 8
 - b. UV ballasts 8
 - c. UV Sensor 1
 - d. Operator Safety Kits: 2
 - e. Cleaning Kit: 1

B. Design and Construction:

1. All metal module components in contact with effluent shall be Type 316 stainless steel.
2. Non-wetted metal components shall be Type 304 stainless steel with the exception of the Lamp Rack Assembly, which shall be constructed of aluminum and be capable of sustaining intermittent pedestrian traffic on the lamp racks.
3. All wiring exposed to UV light within the UV reactor, or electrical ballast enclosure shall be Teflon™ coated.

4. All wires connecting the lamps to the ballasts shall be fully enclosed inside the frame of lamp rack and not exposed to the effluent.
5. The effluent water shall be conveyed through the UV reactor via AFP840™ tubes. There shall be no contact with effluent and quartz sleeves at any time during normal operation.
6. All wetted components in the UV reactor shall be: AFP840™, Type 316 stainless steel PVC, ABS or other non-reactive, non-corrosive material.
7. The UV system (ballasts, lamps, and controls) shall be capable of 24 on/off cycles per 24-hour day for the full specified warranty life of the lamps and ballasts.

2.03 LAMP ARRAY CONFIGURATION

- A. The lamp array configuration shall be a uniform array with all lamps parallel to each other and to the flow.
- B. The UV reactor shall be designed to avoid any immersion of UV lamps in the effluent.
- C. The UV lamps shall be arranged around the outside of the AFP840™ tubes in such a way that each AFP840™ tube shall have no less than six (6) lamps irradiating at all times.

2.04 INLET/OUTLET FLOW DISTRIBUTION

- A. Each UV reactor shall have an inlet and outlet tank. Plant effluent piping shall connect to each of the tanks to convey effluent through the UV reactor.
- B. Connection to inlet and outlet tanks of UV reactor:
 1. Diameter: 12.0 inches (ASME/ANSI B16.5, CL 150 Flange)
- C. Each UV reactor shall have a flow distribution sheet, so as to distribute wastewater efficiently through the AFP840™ tubes.
- D. The tanks and inlet flow distribution sheet shall be made of 304 stainless steel. All material which comes in contact with the wastewater shall be non-corrosive.

2.05 AFP840™ TUBE ULTRAVIOLET REACTOR

- A. Within the UV reactor, AFP840™ UV transmitting tubes are arranged in a horizontal and vertical array. These AFP840™ tubes are in a parallel mode and are attached at one end to the inlet flow distributor sheet and to the outlet flow distributor sheet with appropriate leak proof fittings. The AFP840™ tubes shall be adequately supported.
- B. In between and around the AFP840™ tubes, lamp rack assemblies shall be placed in such a layout to provide uniform and adequate UV light intensity. The lamp racks slide in and out between and around an AFP840™ tube array.
- C. Within the AFP840™ UV reactor, all UV sensitive materials shall be protected from the UV light.
- D. The flow path through the AFP840™ tubes shall achieve optimized plug flow regime. The flow of wastewater should be in sufficient turbulent mode; therefore, the Reynold's number in

each UV reactor would be greater than 50,000 at peak flow. A turbulent flow shall be in such a way that it scours the inner walls of the AFP840™ tube to help prevent scaling or fouling.

- E. The UV reactor shall be covered from five (5) sides with either coated aluminum or stainless panels. The sixth side (top) shall have access door(s). The lamp racks shall be accessible through these doors.
- F. The air temperature inside the AFP840™ UV reactor shall be maintained between 32°C to 49°C or 90°F to 120°F by means of a heat exchanger. The control of the reactor's temperature shall ensure optimum UV light emissions from the UV lamp.
- G. A temperature sensor shall be installed within the UV reactor for protection against heat build-up under no or low flow conditions.

2.06 UV LAMPS:

- A. The UV lamps shall have the following characteristics.
 - 1. A low pressure, high output (LPHO) non-amalgam mercury vapor lamp of the hot cathode type.
 - 2. The filament shall be of the clamped design, significantly rugged to withstand shock and vibration.
 - 3. Each lamp will produce at least 90% emissions at the germicidal frequency of 253.7 nanometers (254 nm).
 - 4. The power consumption shall be a maximum of 138 input watts per lamp, total including ballasts losses shall not exceed 145 watts including ballast losses.
 - 5. The rated UV output at 253.7 nanometers (nm) shall be a nominal 55 UVC Watts at 100 hours of operation.
 - 6. The lamp shall have a minimum UV intensity of 400 microwatts/cm² at 1 meter.
 - 7. Each lamp shall have a rated life of 12,000 hours.
 - 8. Each lamp shall be single-ended. Each lamp shall have a nominal arc length of 1,400 mm.
 - 9. Each lamp has a minimum length of 1,554 mm.
 - 10. Each lamp shall produce no measurable amount of ozone.
 - 11. Each lamp envelope is made of fused quartz and is capable of transmitting at 90% of UV light at 253.7 nm.
 - 12. Electrical connections shall be at one end of the lamp and have six (6) pins, dielectrically tested for 2,500 volts. Lamps that have two (2) to four (4) pins (instant start) may be considered. To be considered as an alternate, instant start lamp systems shall supply replacement spare lamps equal to 20% of the total number of lamps in the system.

13. Each UV lamp shall have a smart lamp Module (an integral unique lamp identification chip) embedded in the lamp pin connector that enables the lamp position in the UV reactor to be altered independent of a lamp holder. The smart lamp module shall be capable of measuring and storing at a minimum the following data for each UV lamp in a reactor.
 - a. Part and Serial number (unique identification) of each individual UV lamp
 - b. Total accrued run time hours
 - c. Lamp ON/OFF cycles

2.07 UV LAMP RACKS

- A. The UV lamp racks shall be placed between rows of the AFP840™ tubes.
- B. The lamp racks shall typically slide in and out within a track that shall be attached to the main frame of the UV reactor.
- C. The use of cranes, hoists or other mechanical lifting devices shall not be acceptable.
- D. The lamp rack assemblies shall be made from aluminum.
- E. Electrical mounting sockets shall be attached to one end of the lamp rack.
- F. The other end of the rack shall have slotted holes to slide lamps in and out during installation and removal of lamps.
- G. Quick power disconnects allow quick disconnect of the lamp rack assembly to the main power at the UV reactor chassis.
- H. Each lamp rack shall be equipped with its own on/off switch and fuse.
- I. Each lamp rack shall be equipped with an LED indicator to identify the operating condition of each lamp on the lamp rack.
- J. Lamp Racks shall be removable for service during UV operation without impacting Hydraulic flow and still maintaining plug flow regime in the reactor.
- K. Each lamp shall be controlled by an individual ballast. Systems that have one ballast controlling multiple lamps shall not be considered.
- L. There shall be no quartz sleeves, O-rings, seals, glands or retainers required to be around the lamps when installed in the lamp racks.

2.08 ELECTRONIC BALLASTS

- A. The ballast used to energize the UV lamps shall be high frequency electronic ballasts. The ballasts shall be housed in the lamp rack assembly as an integral part of the lamp rack.
- B. The electronic ballasts shall be rated at 120 to 277 V +/-10% without discernible change of characteristics.

- C. The electronics ballast shall have the following features.
 - 1. Power factor greater than or equal to 0.95.
 - 2. Electrical conversion efficiency greater than or equal to 90%.
 - 3. Ballast shall have high frequency phase returns from the UV lamps.
 - 4. The ballast operating frequency shall be between 40 and 150 K Hz.
 - 5. The ballast shall have a thermal overload protector to protect against overheating when ballast skin temperature reaches 75°C.

2.09 ELECTRICAL

- A. The UV reactor shall be powered from its own incoming power supply (to be supplied by others).
- B. All cabling, conduit runs and wiring from the plant power supply to the UV reactor shall be as shown on the Contract Drawings.
- C. The Contractor shall be responsible for bringing main and control power to the UV reactor through a branch circuit protections device (disconnect) as shown on the Contract Drawings.
- D. Electrical power required shall consist of the following.
 - 1. Main power to reactor(s): 480 VAC, 3 phase, 4 Wire plus ground (Y) – 10.0 A
 - 2. Control power to reactor(s): 120VAC, 1 phase, 2 wire plus ground – 20.0 A
 - 3. Control power to HMI:.....120VAC, 1 phase, 2 wire – 20.0 A

2.10 POWER PANEL

- A. The power panel(s) for the UV system shall consist of a UL 508-A NEMA 4X rated electrical enclosure. The power panel shall house the following.
 - 1. All contacts, disconnects, terminations and fuses required to power the appropriate bank.
 - 2. Electrical safety lock-out.

2.11 LOCAL CONTROL AND MONITOR

- A. Each reactor bank shall be equipped with an Active Data Router to control and monitor each bank of the reactor. The display for each bank shall be equipped with the following.
 - 1. Two (2) Switch Inputs
 - 2. Two (2) Output Relays:
 - a. Status of unit ON/OFF
 - b. General alarm (Low UV or Lamp out via powered relay)
 - 3. Displays for:
 - a. Individual lamp on indication
- B. Each UV reactor bank shall be equipped with three-way lamp control consisting of; HAND, OFF and AUTO.

1. In Hand:..... Shall provide local lamp control.
2. In Off: Shall power off the lamps in the reactor.
3. In Auto: Shall provide automatic lamp control from remote signal.

2.12 ELECTRONIC DATA CENTER (EDC)

- A. Each UV reactor shall be equipped with an Electronic Data Center (EDC). This system shall collect all the data from individual UV lamps, UV and other sensors in the system and shall display it via a local display and remotely to the plant operation console. The Local display panel shall show the following data.
 1. On/Off status of lamps.
 2. Error Status of lamps and sensors.
 3. An advanced signal for lamp service or replacement.
 4. UV intensity.
 5. The type and location of the alarm.
 6. The frequency of alarms shall be counted and stored.
 7. Alarms and historical operating data shall be stored in a removable storage device in comma delineated format.
- B. Communication between each bank of the reactor and the EDC shall be via CAT5 or CAT 6 Ethernet cable.
- C. Communication between the reactor and HMI shall be via CAT6 Ethernet cable.

2.13 HMI PANEL

- A. The HMI is installed and mounted in a UL 508-A rated enclosure to provide graphic interface for monitoring and control.
- B. The HMI Panel shall be DFI-US Series with Ethernet switch, and shall show all system operational data, system operational history and shall allow access via remote internet connection for troubleshooting and system upgrades.
- C. The HMI enclosure shall house the following.
 1. 19-inch color panel PC.
 2. Electronic Data Center (EDC).
 3. Digital I/Os
 4. There shall be a three-way HOA control for allowing OFF, HAND, or AUTO (automatic) operation of the reactor providing control for the following.
 - a. HAND: Shall provide local lamp control.
 - b. OFF: Shall power off the lamps in the reactor.
 - c. AUTO: Shall provide automatic lamp control from remote signal.

2.14 UV INTENSITY MONITOR

- A. The UV reactor shall have a minimum of two UV intensity sensors (one per bank) which responds to the germicidal portion of light generated. The sensor shall not degrade after prolonged exposure to the UV light or effluent.
- B. The sensor shall measure only the germicidal portion of the light emitted by the UV lamps as measured at 254 nm. It shall have sensitivity at 254 nm of greater than 95%. Sensors whose sensitivity to other wavelengths amounts to more than 5% of the total sensitivity shall not be allowed.

2.15 REMOTE MONITORING AND CONTROL

- A. The Run command for the UV reactor shall be via hard wired connections from the Main Plant's PLC to PIO (port input/output) module located inside the UV control panel. The UV reactor can be turned on or off as required by the Main Plant's PLC/SCADA system by opening or closing dry contacts.
 - 1. With the switches for each bank in the AUTO position, the reactor shall be controlled externally from the HMI panel.
 - 2. Local control (on reactor): The switches shall override the control from HMI panel.
 - 3. Remote Start: One (1) remote start is required as a dry contact. The UV control system shall activate one or two UV banks based on flow.
- B. An isolated 4-20 mA flow signal from the plant effluent flow meter shall to be integrated with the UV control panel at the AIO board.
- C. The UV reactor shall have the capability of providing basic remote monitoring/control via the plants main console (or another designated computer). The plant shall provide either an Internet IP address specific to the UV system, or allow access through its network and via secure website.
- D. Connection/integration to the main console (or customer SCADA system) shall be via MODBUS TCP.

2.16 ALARMS

- A. Minor alarms shall be provided by the EDC's PIO module (Discrete I/O Module) via dry contact, or via MODBUS TCP to indicate to plant operators that maintenance attention is required. Alarms shall include the following.
 - 1. Low UV Intensity shall be pre-set at the factory for 70% of the intensity after 100 hours. Alarm set point shall be field adjustable.
 - 2. Lamp Out
 - 3. Lamp Life
- B. Major alarms shall be provided by the EDC's PIO module (Discrete I/O Module) via dry contact, or via MODBUS TCP to indicate an extreme alarm condition in which the disinfection performance may be jeopardized. Alarms shall include the following.
 - 1. Low UV Intensity Alarm. This alarm shall be pre-set at the factory for 25% of the intensity after 100 hours' burn-in of the lamps. The alarm set point shall be field adjustable. A low intensity alarm shall not cause any bank to turn off.

2. Over temperature alarm
3. Lamp rack power failure
4. High Flow alarm, for flow greater than 3.5 MGD

2.17 CONTROL STRATEGY

- A. Flow Pacing: Assuming the lead bank is bank #1 and that it is in operation during a low flow regime and the flow rate begins to rise the sequence of operation shall be as follows.
 1. When plant influent flow consistently reaches 90% of single bank capacity (1.575 MGD/1,100 gpm) the system shall power on bank #2 in anticipation of the flow to increase greater than 1.75 MGD.
 2. Two UV banks shall be ON for flows between 1.575 MGD and 3.5 MGD.
 3. Flow pacing on falling flows shall follow the same pacing regime in reverse order.
 4. The default setting if system control fails shall be all banks on.
- B. Level Pacing: (UV Dose Pacing): The UV system shall employ a level pacing technique in which the lamps that are not required for maintaining the proper dosage are turned completely off in accordance with the level of the UV inlet channel, while ensuring minimum UV dose delivery at all times. Depending on the water level in the inlet channel, the turndown range (ratio of lamps in lamp rack to lamps used based on liquid level) shall be from as low as 25.0% to 100.0%. Determining water level shall be provided via an integral level sensor using a 4-20 mA signal terminated at the HMI panel.
- C. UV reactor alternation: The alternation of the two (2) UV banks if applicable (duty and standby) shall be performed by the UV Control system to ensure equalized operating hours for the two (2) UV reactors.

PART 3 EXECUTION

3.01 INSTALLATION

- A. INSTALLATION RESPONSIBILITIES OF THE CONTRACTOR
 1. Equipment shall be installed by the Contractor in accordance the Manufacturer's recommendations, drawings and specifications to provide a complete installation.
 2. Provide Manufacturer with at least two (2) week notice prior to any changes in the installation date previously agreed upon by the Owner and Manufacturer.
 3. Sufficient space for moving into place and placement of all equipment supplied by Manufacturer.
 4. Equipment anchoring and grouting including anchor bolts.
 5. All required permits.
 6. Structural work such as concrete pads, mezzanines for elevating equipment items, etc.
 7. Interconnecting electrical outside of the UV Skid limits.

8. Connection and sealing of all flanges, fittings and connections to the adjacent plan processes.
9. All flanges, reducers, elbows, valves and other plumbing appurtenances not specified within these Specifications shall be provided by the Contractor.
10. All electrical components outside the skid limits including, transformers and disconnect switches. Equipment electrical supply shall be detailed on the shop drawings.
11. Protecting the UV reactor from damage between the time of delivery and installation.
12. Equipment unloading, moving and rigging into position.
13. Wiring and conduits for electrical power, controls, and instrumentation shall be provided by the Contractor.

B. INSTALLATION RESPONSIBILITIES OF THE MANUFACTURER

1. Equipment packaging for transportation from Manufacturer's Factory to the job site.
2. All labor to complete the tasks listed as Manufacturer's responsibility shall be performed as straight time rates by employees of a non-union company, or our designated subcontractors.
3. Any deviations from this assumption shall require approval of a Change Order.

C. JOINT RESPONSIBILITY OF THE MANUFACTURER AND THE CONTRACTOR

1. Final assembly and loading of the UV lamps supplied by Manufacturer.

3.02 STARTUP

A. STARTUP RESPONSIBILITIES OF THE CONTRACTOR

1. Provide Manufacturer with a two (2) week notice prior to any changes in the start-up date previously agreed upon.
2. Availability of all required utilities.
3. Availability of typical feed water quality and quantity.

B. STARTUP RESPONSIBILITIES OF THE MANUFACTURER

1. Manufacturer's representative for the equipment specified within this Specification shall be present at the jobsite for a minimum number of workdays for services listed below. Excluded from these time requirements shall be travel time spent, time spent during shipping of equipment, time spent at the jobsite correcting any fabrication or manufacturing errors, and time spent preparing and operating the equipment to meet performance requirements including all performance testing. The Bid shall include all associated expenses incurred by the technical representative during the jobsite visits. The following services shall be provided.
 - a. Two (2) workdays (8 hours each) for maintenance training, maintenance assistance, classroom and on-site equipment operation instructions, troubleshooting, and other post-startup services.

END OF SECTION

SECTION 46 73 20

DIGESTER TANK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Furnish and erect bolted stainless steel storage tank, including the design and construction of the foundation, tank structure, and tank appurtenances, as indicated on the Contract Drawings and Specifications herein. (Size 182,500 gallons working volume).
- B. Section Includes:
 - 1. One (1) circular steel tank
 - 2. Foundation
 - 3. Access platform and stairway
 - 4. Internal and external piping
- C. Related Sections:
 - 1. Section 03 30 00: Cast-in-Place Concrete.
 - 2. Section 03 60 00: Grouting.
 - 3. Section 09 90 00: Painting and Coating.
 - 4. Section 05 50 00: Metal Fabrications.
 - 5. Electrical Division 26

1.02 DESIGN REQUIREMENTS

- A. Design Criteria:
 - 1. Number of Tanks:..... One (1)
 - 2. Tank: 304-Stainless Steel
 - 3. Roof Type:..... Open Top
 - 4. Floor and Foundation Type: Reinforced Concrete of 4,000 psi and 60 ksi rebar
 - 5. Sludge Storage Volume Required: 35,342 cubic feet
 - 6. Freeboard:..... 1.75 feet
 - 7. Side Water Depth: 19.42 feet
 - 8. Dimensions:..... 40-foot diameter x 21.17-foot height

1.03 SUBMITTALS

- A. Section 01 33 00 Submittal Procedures: Submittal Procedures.
- B. Shop Drawings:
 - 1. Submit certified shop and installation drawings showing materials, details of construction, dimensions, control details and electrical wiring diagrams, and performance data.
 - 2. Show complete information concerning fabrication, installation, anchoring, fasteners and other details.
- C. Product Data: Submit Manufacturer's product data for system materials and component equipment.

- D. Manufacturer's Installation Instructions: Submit detailed instructions on installation requirements including storage and handling procedures, anchoring, and layout.
- E. Manufacturer's Certificate
 - 1. Certify products meet or exceed specified requirements.
 - 2. Certify installation is completed in accordance with Manufacturer's instructions and that sludge holding tank is ready for start-up, testing, and operation.
 - 3. Submit Manufacturer's affidavit certifying tank has been designed to resist loading and attest to structural adequacy; calculations shall not be submitted.
- F. Manufacturer's Field Reports: Submit reports of the Manufacturer's inspections and instructions issued.

1.04 CLOSEOUT SUBMITTALS

- A. See Section 01 70 00 Execution and Closeout Requirements of these Specifications.
- B. Project Record Documents: Record actual locations and final orientation of equipment and accessories.
- C. Operation and Maintenance Data: Submit equipment operation and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Perform welding in accordance with ISO 9001. All materials furnished by the tank Manufacturer including vitreous steel panels, joint sealant, encapsulated bolt heads, etc. shall be certified and listed by the National Standard Foundation (NSF) to ANSI/NSF additive standard No. 61.

1.06 QUALIFICATIONS

- A. Manufacturer:
 - 1. ASI Tanks.
 - 2. Pre-qualified engineer-approved equal.
 - 3. Pre-qualified engineer-approved equal manufacturers or suppliers wishing to be considered for this project shall submit to the Engineer at least two (2) weeks prior to Bid Date a full qualification package detailing full compliance with this specification. Manufacturers that do not meet the performance, experience, and quality requirements of this project shall not be pre-approved. Any alternative Manufacturers gaining approval by the Engineer shall be identified via Addendum prior to the Bid Date.
- B. Installer: Manufacturer's personnel directly employed by the equipment Manufacturer and normally engaged in the field installation of the equipment specified herein.
- C. Design tanks, platforms, stairways and other structural components under direct supervision of a Professional Engineer experienced in design of this Work.

1.07 PRE-INSTALLATION MEETINGS

- A. Section 01 30 00 Administrative Requirements: Preconstruction Meeting.

- B. Convene a minimum one (1) week prior to commencing work within this Specification.

1.08 COORDINATION

- A. Section 01 30 00 Administrative Requirements: Coordination and Project Conditions.
- B. Coordinate installation and start-up with the Owner.

1.09 WARRANTY

- A. Section 01 70 00 Execution and Closeout Requirements: Requirements for Warranties.
- B. The tank Manufacturer shall include a warranty for the tank materials and coating. At a minimum, this warranty shall provide assurance against defects in material or workmanship for the period of one (1) year. The tank contractor shall warrant the liquid storage tank shall be free from any defect in workmanship, under normal and proper use, maintenance and operation, during the period expiring on the earlier of (i) one (1) year after liquid is first introduced into the tank or (ii) 14 months after a substantial portion of the tank sheets are delivered to the site where the tank is erected.

PART 2 PRODUCTS

2.01 PLATES AND SHEETS

- A. All steel shall be smelted and produced in the United States of America. Steel Mill Certificates shall be included with the tank submittals to substantiate conformance with this requirement. Plates, structural shapes, and sheet shall be rolled to the necessary diameter to minimize stress during and after assembly.
- B. All plates and sheets used in the construction of the tank shell, tank floor (when supplied) and tank roof, shall comply with the minimum standards of AWWA D103, latest edition.
- C. Design requirements for mild strength steel shall be ASTM A570 Grade 30 with a maximum allowable tensile stress of 14,566 psi.
- D. Design requirements for high strength steel shall be ASTM A607 Grade 50 with a maximum allowable tensile stress of 26,000 psi.
- E. Multiple vertical bolt line sheets and plates of ASTM A607 Grade 50 only shall be manufactured such that holes are staggered in the vertical bolt lines and that no two (2) adjacent holes are in-line horizontally, except at the center of the sheet or plate.

2.02 ROLLED STRUCTURAL SHAPES

- A. Material shall conform to minimum standards of ASTM A36, AISI 1010 or AISC 304.

2.03 HORIZONTAL WIND STIFFENERS

- A. Design requirements for intermediate horizontal wind stiffeners shall be of the "web truss" design with extended tail to create multiple layers of stiffener, permitting wind loads to distribute around the tank. Minimum single length of five (5) feet.

- B. Web truss stiffeners shall be of steel with hot dipped galvanized coating, or stainless steel.
- C. Rolled steel angle stiffeners are not permitted for intermediate stiffeners.

2.04 BOLT FASTENERS

- A. Bolts used in tank lap joints shall be 1/2 inch 13 UNC 2A rolled thread, and shall meet the minimum requirements of AWWA D103, Section 2.2 or ASTM F593.
- B. Bolt Material
 - 1. All bolts, nuts and washers shall conform and be constructed of Type 316 or 305 stainless steel with certifications.
 - 2. SAE Grade 2 (1 inch bolt length)
 - a. Tensile Strength: 120,000 psi minimum.
 - b. Proof Load: 85,000 psi minimum.
 - c. Allowable shear stress with threads excluded from the shear plane – 29,454 psi (AWWA D-103).
 - 3. SAE grade 8/ASTM A490 (bolts length longer than 1-1/4 inches)
 - a. Tensile Strength: 150,000 psi minimum.
 - b. Proof Load: 120,000 psi minimum.
 - c. Allowable shear stress with threads excluded from the shear plane –36,818 psi (AWWA D-103).
 - 4. Bolt Head Encapsulation
 - a. High impact polypropylene copolymer encapsulation of entire bolt head up to the splines on the shank.
 - b. Resin shall be stabilized with an ultraviolet light resistant material such that the color shall appear black. The bolt head encapsulation shall be certified to meet the ANSI/NSF Standard 61 for indirect additives.
 - 5. All bolts on the vertical tank wall shall be installed such that the head portion is located inside the tank, and the washer and nut are on the exterior.
 - 6. All lap joint bolts shall be properly selected such that threaded portions shall not be exposed in the "shear plane" between tank sheets.
 - 7. Bolt lengths shall be sized to achieve a neat and uniform appearance. Excessive threads extending beyond the nut after torquing shall not be permitted.
 - 8. All lap joint bolts shall include a minimum of four (4) splines on the underside of the bolt head at the shank in order to resist rotation during torquing.

2.05 SEALANTS

- A. The lap joint sealant shall be a one component, moisture cured, polyurethane compound. The sealant shall be suitable for contact with potable water and shall be certified to meet ANSI/NSF Additives Standard 61 for indirect additives.
- B. The sealant shall be used to seal lap joints and bolt connections and edge fillets for sheet notches and starter sheets. The sealant shall cure to a rubber like consistency, have low shrinkage, and be suitable for interior and exterior use.
- C. Sealant curing rate at 73°F and 50% RH
 - 1. Tack free time: 6 to 8 hours
 - 2. Final cure time: 10 to 12 days

- D. The sealant shall be Manus Moisture Cured Urethane sealer.
- E. Sika 1A, neoprene gaskets and tape type sealer shall not be used.
 - 1. .

PART 3 EXECUTION

3.01 FOUNDATION

- A. The tank foundation is a part of this Contract and shall be installed by the Contractor. The tank foundation shall be designed in accordance with AWWA D103, latest revision and/or IBC-2006 without exception.
- B. The tank foundation shall be designed by the Manufacturer to safely sustain the structure and its live loads.
- C. Tank footing design shall be based on the soil bearing capacity as determined by geotechnical analysis performed by a licensed soils engineer. Copies of the soil report are included within the Specifications of the overall project, and shall be provided by the Engineer.
- D. Footing designs for soil bearing strengths less than that specified, and those designs deviating from the tank Manufacturer's standard shall be the responsibility of the Owner and the Engineer based on tank live and dead loading data provided by the tank Manufacturer.
- E. Embedded starter shall be 19 inches or 25 inches at a minimum as determined by the Manufacturer.
- F. Slot mount concrete footing or flange mount designs shall not be acceptable.

3.02 TANK FLOOR

- A. The floor design is of reinforced concrete with an embedded stainless steel starter sheet per the Manufacturer's design and in accordance with AWWA D103, Sec 11.4. Slot mount style foundation shall not be acceptable.
- B. Leveling of the starter ring shall be required and the maximum differential elevation within the ring shall not exceed one-eighth (1/8) inch, nor exceed one-sixteenth (1/16) inch within any ten (10) feet of length.
- C. A leveling plate assembly, consisting of two (2) 18" leveling bolts (3/4" dia.) and a slotted plate (3 1/2" X 11" X 3/8" thick) shall be used to secure the starter ring, prior to encasement in concrete. Installation of the starter ring on concrete blocks or bricks, using shims for adjustment, is not permitted.
- D. Place one (1) butyl rubber elastomer water stop seal on the inside surface of the starter ring below concrete floor line. Place one (1) bentonite-impregnated water seal below the butyl rubber seal. Install materials in accordance with the tank Manufacturer's instructions.

3.03 SIDEWALL STRUCTURE

- A. Field erection of the bolted stainless steel tank shall be in strict accordance with the procedures outlined in the Manufacturer's erection manual, and performed by an authorized dealer of the tank Manufacturer, regularly engaged in erection of these types of tanks, using factory-trained erectors.
- B. Specialized erection jacks and building equipment developed and manufactured by the tank Manufacturer shall be used to erect the tanks.
- C. Particular care shall be taken in handling and bolting of the tank panels and members to avoid abrasion of the coating system. Prior to a liquid test, all surface areas shall be visually inspected by the Engineer.
- D. The placement of sealant on each panel shall be inspected prior to placement of adjacent panels. The Engineer's inspection shall not relieve the Contractor from their responsibility for liquid tightness.
- E. No backfill shall be placed against the tank sidewall without prior written approval and design review of the tank Manufacturer. Any backfill shall be placed according to the strict instructions of the tank Manufacturer.

3.04 ROOF

- A. Open top

3.05 APPURTENANCES

- A. Pipe Connections
 - 1. Where pipe connections are shown to pass through tank panels, they shall be field located, saw cut, (acetylene torch cutting or welding is not permitted), and utilize an interior and exterior flange assembly and the tank shell reinforcing shall comply with AWWA D103 latest edition. A single component urethane sealer shall be applied on any cut panel edges or bolt connections.
- B. Outside Tank Ladder
 - 1. An outside tank ladder shall be furnished and installed as shown on the Contract Drawings.
 - 2. Ladders shall be fabricated of galvanized steel, aluminum or stainless steel and utilize grooved, skid resistant rungs.
 - 3. Safety cage and step off platforms shall be fabricated of galvanized steel, aluminum or stainless steel. Ladders shall be equipped with a hinged, lockable entry device as per design or OSHA specifications.
- C. Access Doors
 - 1. One (1) bottom access door shall be provided as shown on the Contract Drawings in accordance with AWWA D103.
 - 2. The manhole opening shall be a minimum of 24 inches in diameter. The access door (shell manhole) and the tank shell reinforcing shall comply with AWWA D103, latest edition, Sec. 5.1. Cover plate shall be supported by a davit.

D. Identification Plate

1. A Manufacturer's nameplate shall list the tank serial number, tank diameter and height, and maximum design capacity. The nameplate shall be affixed to the tank exterior sidewall at a location approximately five (5) feet from grade elevation in a position of unobstructed view.

E. Cathodic Protection

1. A passive cathodic protection system shall be designed and supplied by the tank Manufacturer based upon information supplied by the Engineer or Owner.
2. Attachment of anodes and wiring to the tank structure shall be approved by the tank Manufacturer.
3. When cathodic protection is specified, electrical continuity between sidewall panels shall be the responsibility of the tank Manufacturer.

3.06 FIELD QUALITY CONTROL

- A. Section 01 40 00 - Quality Requirements: Field Inspecting, Testing, Adjusting, and Balancing.
- B. After completion of erection and cleaning of the tank, test tank for liquid tightness by filling the tank to its overflow elevation. Inspect and correct leaks.
- C. Following completion of erection and cleaning of the tank, the structure shall be tested for liquid tightness by filling the tank to its overflow elevation.
- D. Any leaks disclosed by this test shall be corrected by the erector in accordance with the Manufacturer's recommendations.
- E. Water required for testing shall be furnished by the Owner at the time of tank erection completion, and at no charge to the tank erector. Disposal of test water shall be the responsibility of the Owner.
- F. Labor and equipment necessary for tank testing shall be included in the price of the tank.

3.07 MANUFACTURER'S FIELD SERVICES

- A. Section 01 40 00 Quality Requirements: Manufacturer's Field Services.
- B. The equipment Manufacturer is to provide the following.
 1. Detailed operating and installation instructions.
 2. Factory trained representative for a minimum period of one (1) day to perform initial start-up, to instruct Owner's personnel in the operation and maintenance of equipment, and to adjust equipment for satisfactory operation.

END OF SECTION

SECTION 46 73 21
AEROBIC DIGESTER AERATION EQUIPMENT

PART 1 – GENERAL

1.01 SCOPE

- A. This Specification covers the furnishing of an aerobic digester aeration and mixing process for the aerobic digester including compressor, receiver, blowers, control panel, diffused aeration system, nozzle headers, nozzles, instrumentation, auxiliary equipment and accessories as specified herein.
- B. The Aerobic Digester Aeration Equipment shall be pre-selected as stated in Subsection entitled “Manufacturer’s Equipment” in Section 01 20 00 Price and Payment Procedures of these specifications.

1.02 RELATED WORK

- A. Painting, except as specified herein, is included in Division 09.
- B. Instrumentation, except as specified herein, is included in Division 40.
- C. Ductile Iron Pipe, except as specified herein, is included in Division 40.
- D. Pipe Supports, except as specified herein, is included in Division 40.
- E. Valving, except as specified herein, is included in Division 40.
- F. Electrical work, except as specified herein is included in Division 26.

1.03 SYSTEM DESCRIPTION

- A. The system shall control the aeration and mixing of the aerobic digesters, through instrumentation feedback or manual operation of the aeration and mixing devices. The aeration system shall diffuse air into the basin through fixed coarse bubble diffusers located on the basin floor to satisfy process oxygen demand and the mixing system shall intermittently and sequentially inject compressed air through fixed nozzles located on the basin floor to mix the basin contents.

1.04 REFERENCES

- A. ASTM International (ASTM)
 - 1. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications.
 - 2. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - 3. A312, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipe.
 - 4. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.

5. D3915 Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings.
6. D3034 Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
7. A774 Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
8. A554 Standard Specification for Welded Stainless Steel Mechanical Tubing.
9. A778 Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.

1.05 DESIGN CRITERIA

- A. Performance and design requirements of the compressed gas mixing system shall be as follows:
1. Basin mixing shall be uniform throughout the basin with effective mixing confirmed through a Field Performance Test as specified.
 2. Air Distribution and balancing shall be sufficient to maintain suspended solids in a state of suspension over entire depth of basins. The Master Control Panel (MCP) shall allow operator-variable control of firing parameters (pressure, sequence, duration, and frequency) to achieve basin mixing.
 3. Air mixing system equipment and piping shall be sized to thoroughly mix the contents of the basins for which the systems are designed.
 4. Treatment Process.

Basin	Aerobic Digester
Basin Diameter (feet)	40
Side Water Depth (feet)	18
Number of Basins	1
Number of VCPs per Basin	1
Number of ACVs per VCP	3
Number of Nozzle Headers	6
Number of Nozzles per Nozzle Header	Varies
Minimum Number of Nozzles	22
Header Supply Pipe Diameter (inches)	2.0

- B. Performance and design requirements of the diffused aeration system shall be as follows:
1. Diffused aeration system equipment and piping shall be sized to deliver air and process oxygen to the contents of the basins for which the systems are designed.

2. Treatment Process.

Basin	Aerobic Digester
Basin Diameter (feet)	40
Side Water Depth (feet)	18
Number of Basins	1
Number of Air Distributors	1
Number of Diffusers	40
Header Supply Pipe Diameter (inches)	6.0
Oxygen Transfer Rate (lbs/hr)	169
Maximum Air Rate (scfm)	520
Diffuser Submergence (feet)	17
Max Drop Pipe Pressure (psig)	7.7

1.06 SUBMITTALS

- A. Submit all shop drawings in accordance with Section 01 33 00 Submittal Procedures of these Specifications. Include complete assembly drawings and electrical control schematics.
- B. The following items shall be submitted with the Shop Drawings.
 - 1. Catalog data or illustrations showing principal parts and materials.
 - 2. Detailed layout drawings.
 - 3. Electrical schematics.
 - 4. Test or performance data that the system does not contribute measurable oxygen into the process stream.
 - 5. Compressor and blower support locations and loads transmitted to bases and foundations.
 - 6. Compressor and blower electrical schematics and field termination wiring.
 - 7. List of recommended spare parts.
 - 8. Qualifications of field service engineer.
 - 9. Recommendations for short and long-term storage.
 - 10. Special tool requirements.
 - 11. Full scale test results from a minimum of five (5) installations within the United States demonstrating that the Compressed Gas Mixing System achieved homogeneous mixing as substantiated through statistical analysis of Total Suspended Solids (TSS) samples yielding a Coefficient of Variation (Cv) of 10% or less.

12. Installation reference list including a minimum of five (5) Compressed Gas Mixing Installations for which the Supplier furnished and integrated the complete Compressed Gas Mixing System, including, at a minimum, Nozzles, In-Basin Piping, Valve Panels and Compressor. Provide Facility Name/Location, Design Average Daily Flow, Contact Name/Telephone Number and Start-Up Date for each installation.
- C. Submit a complete description of the proposed operating strategy, including operating cycle descriptions for present and future flows.
- D. In addition to the requirements for the plant's O&M Manual, specified elsewhere, the Manufacturer shall supply three (3) copies of a stand-alone, three-ring binders of information for the Owner to utilize in operation and maintenance of the system.
- E. The O&M Manual shall include the following information for the System:
 1. Warranty
 2. Process Guarantee
 3. Operation recommendations regarding the process
 4. Installation recommendations
 5. Maintenance requirements/schedule
 6. Equipment drawings
 7. Equipment technical data

1.07 SUPPLIER EXPERIENCE

- A. The supplier shall have a minimum of eight (8) installations operating within North America.
- B. The supplier shall have a combined operational experience of greater than ten (10) years.

1.08 QUALITY ASSURANCE

- A. The system shall be furnished by a single Manufacturer who is fully experienced, reputable and qualified in the manufacture of the equipment to be furnished. The equipment shall be designed, constructed, and installed in accordance with the best practices and methods and shall be as manufactured by EnviroMix, Inc. of Charleston, SC, or Engineer approved equal. The Contractor shall obtain the nozzles, nozzle headers, header supply piping, panels, compressors, receivers, diffused aeration, blowers, instrumentation and appurtenances from the system Manufacturer, as a complete and integrated package to insure proper coordination and compatibility and operation of the system.
- B. Alternate Manufacturers wishing to offer their equipment must submit the following information to the Engineer in a Pre-Qualification Package within twenty-one (21) days prior to the published date of Bid Closing. Engineer shall evaluate information and if, in the Engineer's sole discretion, the Alternate Manufacturer's proposed system meets the specification, performance and offers equal quality and experience to the basis of design, the Alternate Manufacturer shall be added to the specification via addendum. The following information shall be submitted:
 1. A complete set of project specific drawings, specifications, catalogue cut sheets, and detailed descriptive material of proposed major equipment items. This information shall

identify all technical and performance requirements stipulated on each drawing and in each specification section.

2. Full scale test results from a minimum of five (5) U.S. installations demonstrating that the Compressed Gas Mixing System achieved homogeneous mixing as substantiated through statistical analysis of Total Suspended Solids (TSS) samples yielding a Coefficient of Variation (Cv) of 10% or less.
 3. Test or performance data that the Compressed Gas Mixing System does not contribute measurable oxygen into the process stream.
 4. Full scale test results from a minimum of two (2) installations within the United States demonstrating that the Compressed Gas Mixing System does not negatively impact biological nitrogen and/or phosphorus removal.
 5. Written confirmation from Authorized Officer of the Company that the proposed compressed gas mixing system includes complete Unit Responsibility with all components specified in this specification, as well as the specified Field Performance Testing and Guarantee.
 6. Installation reference list including a minimum of ten (10) Compressed Gas Mixing Installations for which the Supplier furnished and integrated the complete compressed gas mixing system, including, at a minimum, nozzles, in-basin piping, valve panels and compressors. Provide Facility Name/Location, Design Average Daily Flow, Contact Name/Telephone Number and Start-Up Date for each installation.
 7. List of recommended spare parts.
 8. Equipment field installation requirements.
 9. A maintenance schedule with projected labor hours showing the required maintenance, frequency of maintenance, lubricants and other items required at each regular preventative maintenance period.
 10. Reviewed specification with each paragraph marked noting full compliance and detailed written documentation with discussion of all deviations from the specification.
 11. Letter from a Surety indicating that the Manufacturer is pre-approved to receive a five (5) year performance bond.
- C. Should the Contractor choose equipment from a Manufacturer of an acceptable alternate product, any additional costs required to accommodate such equipment, including any changes to the field air piping, power distribution or additional Engineer review time, shall be made without a change in the Contract Price or Contract Time and at no additional cost to the Owner
- D. A performance bond from the Manufacturer guaranteeing the replacement of the acceptable equivalent product shall be provided with the submittal package. The bond term shall be for a period of five (5) years. If the operation of the acceptable alternative compressed gas mixing system as determined by the Owner is unsatisfactory, the Contractor shall repair, modify or replace the entire system to include the compressed air equipment system with appurtenances, in a manner acceptable to the Owner. If the Contractor fails to correct deficiencies identified by the Owner within six (6) months of the date first notified in writing, the Owner shall, at its own discretion make all necessary repairs or replacement and deduct all associated costs from the performance bond.

1.09 WARRANTY

- A. The Supplier shall provide a warranty on the equipment furnished in this Specification.
- B. Warranties for all parts and labor shall be for one (1) year from date of written acceptance by the Owner, not date of delivery.
 - 1. Warranty shall include all parts and labor to correct defects.
 - 2. Warranties by the Suppliers of various components in lieu of a single-source responsibility by the Manufacturer shall not be accepted.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. The Supplier shall recommend packing and preparation for shipment and handling.
- B. Storage and protection shall be as recommended by the Supplier.
- C. Ship each component in as few parts as possible.

1.11 SPARE PARTS

- A. Instrumentation
 - 1. One (1) ORP Probe
 - 2. One (1) DO Probe
- B. Positive Displacement Blowers
 - 1. One (1) Air filter for each blower type
 - 2. One (1) Set of Belts for each blower Type

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. EnviroMix, Inc.
- B. Pre-qualified engineer-approved equal.
- C. Pre-qualified engineer-approved equal manufacturers or suppliers wishing to be considered for this project shall submit to the Engineer at least two (2) weeks prior to Bid Date a full qualification package detailing full compliance with this specification. Manufacturers that do not meet the performance, experience, and quality requirements of this project shall not be pre-approved. Any alternative Manufacturers gaining approval by the Engineer shall be identified via Addendum prior to the Bid Date.

2.02 SCOPE OF SUPPLY

- A. Compressed Gas Mixing System:
 - 1. Header Supply Piping.
 - a. Provide threaded connections only where required.

- b. Schedule 5S stainless steel Press technology system (Viega, or equal), comprised of stainless steel Press technology fittings, couplings, and pipe, unless specified otherwise.
 - c. Maximum working pressure of 200 psi.
 - d. Couplings and fittings: Press technology products formed of Type 304/304L stainless steel tubing including a self-contained O-ring seal(s) molded of synthetic FKM rubber.
 - e. Pipe: Type 304/304L ASTM A312 stainless steel.
- 2. Nozzle Headers.
 - a. 4L stainless steel with 1-inch Schedule 40S, stainless steel nozzle offsets
 - b. Nozzle couplings: 1-inch NPT, 150 lb, Type 304/304L stainless steel
 - c. Delivered from the Manufacturer pre-assembled to the extent practicable to minimize field assembly error and installation time.
 - d. Pipe: Type 304/304L ASTM A312 stainless steel.
 - e. Provide nozzle headers in maximum 20-foot segments with two (2) bolt Type 304/304L stainless steel flexible gasketed coupling connections and removable end caps. Flexible couplings shall be rated for a maximum working pressure of 150 psi.
- 3. Nozzles.
 - a. Top plate fabricated from 1/8-inch thick stainless steel plate, ASTM A240/A240M, Type 304/304L with a 2D finish.
 - b. Bottom plate fabricated from HDPE and gasketed to prevent air from leaking between the top plate and the bottom plate.
 - c. Top and bottom nozzle plates shall be joined together using Type 304/304L stainless steel hardware. Nozzles shall come pre-assembled.
 - d. Adequate strength to withstand vertical thrust of mixing air.
 - e. Threaded Rod Anchors: Use Hilti HIT-RE 500 adhesive or equal to be provided by the contractor. A minimum of two threaded rods shall be installed per nozzle for flat floor installations, one each on opposite diagonal corners. Three (3) threaded rods shall be installed per nozzle for slope floor installations.
 - f. Nozzles shall be installed in the locations as shown on the Contract Drawings.
- 4. Appurtenances.
 - a. Miscellaneous: Nuts, bolts, washers, threaded rod, and other non-welded parts shall be stainless steel, ASTM A240/A240M, Type 304. Threaded assemblies shall be chemically treated or lubricated prior to assembling to prevent galling.
- 5. Fabrication.
 - a. The piping used for the air mixing system shall be Type 304/304L stainless steel unless otherwise noted.
 - b. Shop fabricate welded metal parts and assemblies from stainless steel, ASTM A240/A240M, Type 304/304L with a 2D finish.

- c. Shop fabricate non-welded parts and pieces from sheets and plates of stainless steel, ASTM A240/A240M, Type 304 or from bars of stainless steel ASTM A276, Type 304, unless specified otherwise.
- d. Welds and Welding Procedure
- e. Shop weld with filler wire using MIG, TIG or shield-arc, or plasma-arc welding inert gas processes. Provide a cross-section equal to or greater than parent metal.
- f. Provide full penetration welds to interior surface with gas shielding to interior and exterior of joint.
- g. Provide smooth, evenly distributed interior weld beads with an interior projection not exceeding 1/16 inch beyond inner diameter of nozzle header or fittings.
- h. Field welding is not permitted.
- i. Clean all welded stainless steel surfaces and welds after fabrication to remove weld splatter and finish clean all exterior welds, carbon deposits and contaminants per ASTM A380 Section 6.2.11

B. Course Bubble Diffused Aeration System

1. Drop Pipes.

- a. Provide a minimum 12 gauge stainless steel drop pipe from the air main connection to a point 3 feet above the manifold.
- b. Provide a stainless steel flange with a 150-pound drilling at the top connection.
- c. Provide a stainless steel gasketed coupling for connection to the manifold.
- d. Fabricate all welded parts and assemblies from sheets and plates of 304L stainless steel with a 2D finish conforming to ASTM A240, 554, 774, 778.
- e. Fabricate non-welded parts and flanges from sheets, plates or bars of 304 stainless steel conforming to ASTM A240 or ASTM A276.
- f. Weld in the factory with ER 316L filler wire using MIG, TIG or plasma-arc inert gas welding processes. Provide a cross section equal to or greater than the parent metal.
- g. Clean all welded stainless steel surfaces and welds after fabrication to remove weld splatter and finish clean all interior and exterior welds by full immersion pickling and rinse with water to remove all carbon deposits and contaminants to regenerate a uniform corrosion resistant chromium oxide film per ASTM A380 Section 6.2.11, Table A2.1 Annex A2 and Section 8.3.

2. Manifolds and Air Distribution Headers.

- a. Provide minimum 12 gauge stainless steel manifolds and air distribution headers for connection to the drop pipe.
- b. Fabricate maximum 40 feet long manifolds and air distribution headers with flanged joints or expansion joints.
- c. Design piping with eccentric reducers for changes in diameter to maintain constant invert elevation.
- d. Provide piping with removable end caps.

- e. Design piping, pipe joints and supports to resist expansion/contraction thrust forces of the air distribution headers over a temperature range of 125°F.
 - f. Provide piping fabricated of stainless steel material per Subsection 2.04.A within this Specification.
3. Pipe Supports.
- a. Provide each section of manifold and air distribution header with a minimum of two (2) supports.
 - b. Support spacing to be limited to a maximum of 18 feet.
 - c. Design all supports to allow for thermal expansion and contraction forces over a temperature range of 125°F, and to minimize stress build up in the piping system.
 - d. Design supports to be adjustable without removing the air distribution header from the support.
 - e. Design supports to include hold down guide straps, support structure and two anchor bolts.
 - f. Design guide straps with a 2-inch minimum width to eliminate point load on piping and minimize binding.
 - g. Design support for a total of 1 inch lateral adjustment and 4 inch vertical adjustment for leveling within 3/8 inch of a common plane.
 - h. Attach supports to tank floor with stainless steel anchor bolts.
4. Air Diffuser.
- a. Provide diffuser fabricated of stainless steel material per section 2.04.A.
 - b. Design diffuser with cast stainless steel alloy equivalent to 304L stainless steel Schedule 80 3/4"-inch NPT threaded nozzle, air reservoir, air exit ports and bottom deflector.
 - c. Design diffuser with a minimum air release perimeter of 48 inches.
 - d. Locate exit ports discharging air into liquid on horizontal planes at two (2) levels.
 - e. Provide deflector below each diffuser for its full length and width.
 - f. Design deflector to direct the liquid being aerated along the diffuser reservoir walls so that the air exits through the ports and is sheared into small bubbles and distributed into the liquid.
5. Diffuser Connector.
- a. Design diffuser connector for two (2) diffusers.
 - b. Furnish PVC plugs for all unused diffuser connectors.
 - c. Design diffuser connector with cast stainless steel alloy equivalent to 304L stainless steel.
 - d. Provide connector so that air exiting the diffusers does not interfere with the air distribution header.
 - e. Factory weld connector to the invert centerline of the air distribution header with a full penetration butt weld.

- f. Reinforce the connector header weld joint by providing and continuously welding gussets between the vertical side wall of the header and the connector ends to limit long term flexure failure. Minimum gusset thickness shall be 1/8 inch.
 - g. Design connector to resist a vertical dead load applied to the threaded end of the connector that results in a bending moment of 1,000 inch-lbs without exceeding 24,000 psi design stress in any part of the air distribution header wall or connector.
6. Anchor Bolts. Design a mechanical or adhesive anchor bolt system for embedment in 4,000 psi concrete with a pullout safety factor of 4.

C. Control Panels

1. Master Control Panel (MCP) Enclosure. MCP shall have UL-rated NEMA 4X 304 stainless steel enclosures. Control panels shall be sized to provide heat dissipation such that, at a 110°F ambient temperature, the operating temperature rating of the lowest-rated component in the panel is not exceeded.
2. MPC Cover. The MCP shall be provided with a cover for the Operator Interface to protect against sun and rain when located outdoors.
3. Power Connection. All panels shall accept a single source 120 VAC power connection. Lightning and surge protection shall be provided on the incoming line power. Lighting and surge protection shall be Phoenix Contact Mains Plugtrab or equal.
4. MCP Operator Interface Terminal (OIT). The MCP shall have an OIT to make operating parameter changes and acknowledge alarms. The OIT shall be a Allen Bradley PanelView 10-inch color touchscreen. The OIT shall have flash memory capacity, USB port, and Ethernet communication.
5. Controller. The control panel shall be equipped with an Allen-Bradley Compact Logix controller which controls the sequence, duration, and frequency of ACV openings. The controller shall provide alarming functionality and network communication capabilities via Ethernet TCP/IP protocols.
6. Back-Up Controller. The control panel shall be equipped with a factory programmed controller back-up to automatically take over control of the ACVs in the event the controller is disabled and automatically relinquish control when the primary controller is enabled. The back-up controller shall be programmed to operate with factory settings for valve firing sequence, frequency and duration. The controller back-up shall be rated for Class I, Division 2 Hazardous Areas.
7. Air Control Valves (ACVs). The air control valves shall be spool type control valves, mounted to a common manifold. Under normal operating conditions the valves shall be rated for 15,000,000 cycles. Valves shall vent to the outside of the panel.
8. Throttling Valve. The VP shall be equipped with a throttling valve to adjust the volume of air released to the ACVs and corresponding header supply piping. The throttling valve shall be pre-plumbed into the VP.
9. Control Air Filter. The VP shall include a pre-plumbed 5-micron filter with a drain to remove fine particles, water vapor, and oil from the air supply. The filter shall be Watts F603D or approved equal.
10. Heater. The control panel located outdoors shall be provided with a 120 VAC heater designed to maintain 40°F in an ambient outside temperature of 20°F. The heater shall be equipped with a thermostat to turn the heater off at temperatures above 40°F.

11. Nameplate. A stainless steel nameplate shall be provided on the control panel. The nameplate shall be securely fastened in a conspicuous place and clearly inscribed with the Manufacturer's name, year of manufacture, and serial number.
12. System Start-up Monitoring. During the warranty period, the Master Control Panel or a dedicated Valve Control Panel shall have a web-enabled gateway to communicate asset-level detail in real-time to a secure cloud-based portal. Manufacturer personnel shall utilize performance data to monitor the mixing system during the initial warranty period, and ensure optimized system performance and servicing. Operating data shall be transmitted via secure outbound (DHCP Firewall compatible) connections directly to the cloud server via internet connection provided by the facility. Separate network segments for internet access, and the monitored equipment is recommended but not required. The gateway shall be capable of virtual private network (VPN) tunneling on an as-needed basis for routine software updates, implementation of customer specific customizations, and remote technical support. The VPN functionality may be interlocked with a local switch such that access must be physically initiated by plant personnel. Specific SMS and email notifications can be generated automatically and sent to the mixing system Manufacturer as well as designated facility operators and administrators. Notifications may include information such as:
 - a. Mixing Status (enabled/disabled)
 - b. Valve specific fail to open alarms
 - c. Valve specific service alerts
 - d. Low pressure alarm
 - e. Compressor run status and total runtime (each compressor)
 - f. Compressor fault (each compressor)
 - g. Compressor service alert (each compressor)
 - h. Blower run status and total runtime (each blower)
 - i. Blower fault (each blower)
 - j. Blower service alert (each blower)

D. Control and Operation

1. All control features shall be adjustable from the Operator Interface Terminal (OIT) provided by the Manufacturer. Control features shall be adjustable at any time during the operation of the system. Control features shall be initially set according to the Manufacturer's recommendations.
2. Mixing Parameters. The operator shall be able to enable/disable mixing operation, select the firing sequence, the firing duration and the frequency of firing. Minimum control features selected through the OIT shall include the following:
 - a. Enable / Disable. ACV firing can be started and stopped at any point during operation without powering down the system.
 - b. Firing Sequence. Order and operation in which ACVs are fired, e.g. 1,2,3,..8 1,1,2,2,3,..8 8,1,7,2,..1.

- c. Firing Duration. Length of time an individual ACV is open during a firing event. The duration shall be operator adjustable within programmed limits and configurable for each ACV individually.
 - d. Firing Frequency. Length of time to complete the firing sequence. Frequency shall be operator adjustable within programmed limits.
 - e. Valve Isolation. Individual ACVs or specific groups of ACVs may be added and/or removed from the firing sequence at any point during operation.
3. Process Parameters. Minimum control features shall include the following:
 - a. DO: Range of DO setpoints for blower/compressor operation.
 - b. ORP: Range of ORP setpoints for blower/compressor operation.
 - c. Manual: Operator selectable blower/compressor operation independent of DO or ORP.
 4. Alarms. Each VP shall come equipped with a pressure transducer plumbed to the valve manifold. The pressure transducer shall transmit pressure anomalies to the controller. The controller shall interpret the pressures transmitted to provide a low system pressure alarm and monitor ACV position.
 5. Alarm Indication. When either the low system pressure or Valve Fail to Open alarms occur, a red general alarm light shall be illuminated on the VP. The specific alarm shall be indicated on the alarm shall remain until the fault is corrected or the system is turned off.
 6. Heartbeat Function. The controller shall have a register with a bit that toggles at a regular interval to act as a heartbeat for confirmation of continued controller operation and network communication.
 7. The controller shall communicate the following through Ethernet:
 - a. System pressure
 - b. Firing sequence
 - c. Firing frequency
 - d. Firing duration (each valve)
 - e. System running (enabled)
 - f. Low pressure
 - g. Valve fail to open (each valve)
 - h. General alarm
 - i. Heartbeat
 - j. Blower fault (each blower)
 - k. Blower run (each blower)
 - l. Blower over temperature
 8. The controller shall accept the following parameters through Ethernet:
 - a. Enable Mixing
 - b. Firing sequence (up to 16 firing events)

- c. Firing frequency
- 9. Firing duration (each valve)

E. Air Compressors

1. High Pressure Air Compressors

- a. One (1) air compressor modules shall be as noted in the Design Table below. Each shall include an inlet air filter, compressor with an AC motor, air/oil separator reservoir, air-cooled oil cooler, cooling fan, separator pressure relief valve, discharge check valve, moisture separator, filters, controls, control panel, base, and unloading system.
- b. The compressor module shall be completely factory assembled requiring only field connection of electrical power, and air and condensate drain piping.
- c. The compressor shall be of the single stage, positive displacement, oil-flooded, rotary screw type. The compressor shall be provided with an integral skid or lifting lugs for unloading and placement.
- d. The compressor rotors shall be asymmetrical, steel or high strength ductile iron integral shafts, and dynamically balanced. Housings shall be cast iron. Rotors and housings shall be precision machined for accurate bearing positioning and running clearances. The drive arrangement shall be a gear driven design.
- e. Positive pressure lubrication shall be provided by an inherent pressure differential system. Lubricant shall be provided as recommended by the Manufacturer. A lubricant filter shall have a high-capacity 10 micron rating.
- f. An air/oil separator reservoir shall be provided for the compressor. The reservoir shall be designed and constructed in accordance with the ASME Code for Unfired Pressure Vessels and shall bear the code stamp. The reservoir shall include two-stage filtration to remove oil from air stream. Oil carry-over downstream of compressor modules shall not exceed 3 mg/m³.
- g. The air compressor module shall have automatic controls integral to the unit which open (loaded condition) and close (unloaded condition) the inlet valve to the air end to deliver appropriate volume to meet demand and maintain system target pressure. On sensing a low demand, the motor shall keep running but the air end inlet valve shall close, resulting in a decreased "idling" power draw on the motor. The valve shall reopen when system pressure drops below the set point.
- h. The baseplate shall be constructed of one-piece folded mild-steel with structural members and shall be designed for no measurable deflection with the equipment mounted thereon and the baseplate supported around its perimeter. The base shall be designed so that all equipment bolted to it can be removed without access to the underside of the plate and with a flat top surface for ease of cleaning. Structural stiffeners shall be located under the compressors at the compressor anchor points.
- i. Valves and piping within the enclosure shall be the compressor Manufacturer's standard. Relief valves shall be provided for equipment protection on the air and coolant systems as required.
- j. The compressor shall be provided with an integral, dry-type intake filter. Intake filters shall have replaceable filter element(s). Particle arrestance shall be not less than 99.9% efficient at 10 microns and above.

- k. The compressor shall be supplied in a sound attenuated enclosure. The enclosure shall reduce the measured sound to a maximum of 85 decibels, as measured by ISO 8571, while the compressor is operating and the sound level is measured a distance of three feet from the enclosure.
 - l. The compressor electrical control cabinet shall be a NEMA 3R rated enclosure.
 - m. A high air/fluid temperature shutdown system shall be provided. The unit must have safety devices mounted and wired. Safety devices shall include motor thermal overload and high compressor discharge temperature shut-down. These systems must be designed to prevent the compressor from running in an "over temperature" situation or motor from running in an overload condition.
 - n. The compressor shall be as manufactured by Atlas Copco, Model GA7, or equal.
2. Refrigerated Dryer
 - a. An air dryer shall be provided of cycling refrigerated air type. The dryer shall produce an ISO Class 4, 70°C dew point at the dryer exit when operating continuously at the rating conditions of 20°C and RH of 60%.
 - b. The dryer shall be capable of continuously drying the maximum discharge capacity of the air compressor.
 - c. The dryer shall be integral or separately mounted to the compressor package.
 3. Integral Air Receiver
 - a. One air receiver shall be integrally mounted to the compressor. The receiver shall be designed and constructed in accordance with the ASME Code of Unfired Pressure Vessels and shall bear the code stamp.
 4. Compressor System Particulate and Coalescing Oil Filters
 - a. Replaceable-cartridge primary particulate and secondary high-efficiency oil-removal filters shall be provided for the compressor package. Following both filters, the maximum particulate size removal shall be to 1 micron and coolant removal shall be to 0.1 mg/m³ at 21°C.
 - b. The filters shall be rated for the maximum discharge capacity of the air compressor.
 5. Compressor System Electrical
 - a. All electrical and control equipment for the air compressor module shall be furnished as required for a complete installation, requiring only field connection of 480 VAC, three phase power supply
 - b. The compressor electric motor shall be rated 480 volts, 60 Hz, 3 phase.
 6. Compressor System Control Panel – An enclosure-integrated control panel mounted on the compressor module shall include:
 - a. Full voltage, non-reversing, motor starters sized as required by the Manufacturer.
 - b. Control power transformers shall have both primary leads fused, one secondary lead fused, and one secondary lead grounded.
 - c. Terminal blocks for all system wiring. Internal panel wiring shall be neatly bundled and tied and shall be identified with suitable wire markers

- d. Controller shall be provided to indicate the following conditions; Differential pressure across fluid filter, discharge pressure, compressor discharge temperature, power on, hours of operation, operating mode, differential separator, percent capacity, air filter.
 - e. A contact which closes under alarm conditions shall be provided for the compressor for remote "FAIL" alarm. The contact shall close when any alarm occurs for the compressor.
 - f. Remote mounted fusible disconnects with time delay fuses shall be provided by Contractor.
7. Compressor Shop Painting
- a. All components of the compressed air equipment system shall be shop primed and finish painted with the Manufacturer's standard paint system prior to shipment to the site.
8. Compressor System Performance and Design Requirements.
- a. The compressed air equipment shall be designed for the following operating conditions:

Ambient Conditions		
	Max Air temperature (°F)	115
	Min Air temperature (°F)	32
	Relative humidity (%)t	80
	Barometric pressure (psia)	14.6
Compressors		
	Number required	1
	Maximum discharge pressure (psig)	100
	Capacity at discharge pressure (acfm)	44
	Motor size (HP)	7.5
	Max free field noise level (with enclosure) measured as rated by ISO 2151 test standards (dBA)	70
Receivers		
	Number required	1
	Design pressure (psig)	200
	Nominal volume (gal)	132
Coalescing Filters		
	Type	Particulate and Oil Removal
	Number required	1
Refrigerated Air Dryer		

Type	Cycling
Number required	1
Target Pressure Dew Point (°C)	2 to 3

F. Positive Displacement Blowers

1. Positive Displacement Blowers.

- a. Furnish all labor, materials, equipment and incidentals required and install complete, ready for operation and field-test two (2) new rotary positive displacement blower packages and appurtenances as specified herein.
- b. Packages shall be Aerzen Generation 5 Delta Blower Model GM 35S, or equal. Regardless of Manufacturer, the package shall be produced by the Manufacturer of the blower stage, to ensure single source responsibility for blower performance and compatibility of associated accessories.

2. Blower System Performance and Design Requirements.

a. Requirements.

Quantity	2
Discharge Pressure (psig)	8.6
Motor Horsepower (hp)	75
Max. Brake Horsepower (bhp)	60
Inlet Volume (scfm)	1060
Elevation (psia)	700
Inlet Air Temperature (°F)	100
Relative Humidity (%)	80
Max free field noise level measured as rated by ISO 2151 test standards (dBA)	75

3. Blower Casing

- a. The blower casing shall be of one-piece construction, with separate sideplates that are bolted and pinned to the housing.
- b. Materials shall be close-grained cast iron ASTM A48 suitably ribbed to prevent distortion under the specified operating conditions.
- c. Minimum blower casing pressure rating shall be 36 psig.
- d. Inlet and outlet shall be flanged connections.
- e. The casing shall incorporate a proven means of pulsation cancellation.
- f. The vibration level as measured at the blower casing, in the X/Y planes of the bearings, shall not exceed 1/2" per second RMS when operating at the specified maximum operating pressure and speed in the actual blower package.

4. Factory Testing.

- a. Each blower stage shall be factory tested in accordance with ISO 1217 performance test to verify flow and brake horsepower at blower maximum conditions. A slip test shall not be acceptable, nor is average data for the manufactured size.

- b. The acceptance criteria are +5% tolerance on power and –5% tolerance on flow regardless of the size of the machine.
- 5. Rotors.
 - a. Each rotor shall be of the “stiff” design with first lateral critical speed at least 120% of the maximum allowable operating speed.
 - b. The rotors shall be of the straight, three-lobe type, and shall operate without rubbing or liquid seals or lubrication.
 - c. Rotor/shaft shall be drop forged in one single piece of AISI 1043 or equivalent. Cast, hollow rotors shall be capped, dust tight. Open rotors shall not be acceptable.
 - d. The rotors shall be statically and dynamically balanced per ISO1940/ANSI S2.19 G6.3.
- 6. Bearings.
 - a. Each rotor/shaft shall be supported by anti-friction bearings, and fixed to control the axial location of the rotor/shaft in the unit.
 - b. Regardless of theoretical bearing life calculations, the bearings shall be sized for a minimum expected life of five (5) years between overhauls. Calculated bearing life shall be submitted, based on specified operating conditions.
- 7. Timing Gears.
 - a. The rotors shall be timed by a pair of single helical AGMA 12 quality gears with hardened and ground teeth; minimum AGMA service factor of 1.70. Spur cut gears shall not be acceptable.
 - b. Gears shall be mounted on the shafts with a tapered interference fit, and secured by a locknut. Pinned gears shall not be acceptable.
- 8. Seals.
 - a. Seal shall be designed to prevent lubricant from leaking into the air stream as well as to prevent oil from leaking out of the machine.
 - b. Four rotary piston ring shaft seals, an oil slinger and an O-ring seal shall be provided at the point where the shaft passes through the sideplates.
 - c. Further provision shall be made to vent the rotor side of the oil seal to atmosphere to eliminate any possible carry-over of lubricant into the air stream.
- 9. Lubrication.
 - a. The timing gears and the bearings shall be splash lubricated. Grease lubrication shall be not acceptable.
- 10. Oil Sight Glass.
 - a. A recessed oil sight glass must be provided on each oil sump.
 - b. Protruding sight glasses shall not be acceptable.
- 11. Painting.
 - a. Painting shall be per supplier’s standard meeting the following criteria:
 - i) Except for machined sealing and machined mounting surfaces, the package shall be painted dark blue.

- ii) Aluminum, stainless steel, and brass shall not be painted.
- iii) The supplied motor shall not be over sprayed and shall be supplied with the motor Manufacturer's standard protection and paint color.
- iv) Painted Cast Iron and Carbon Steel shall be Alkyd Resin Primer and Final coat with a total dry film thickness of 70 μm . Surface preparation SSPC10 or better.
- v) Sound enclosure shall be powder-coated polyester base total dry film thickness of 80 μm .
- vi) Components shall only be painted with appropriate surface preparation

12. Inlet Filter Silencer.

- a. Each package shall be supplied with one (1) combination inlet filter silencer.
- b. The inlet filter silencer shall be mounted directly to the inlet flange of the blower.
- c. The filter media efficiency must meet the requirements of ASHRAE 52.2 MERV7 50-70% at 3 to 10 microns corresponding to EN779 G4.
- d. The silencer portion shall be located upstream of the inlet filter.
- e. Filter and silencer performance losses shall be included in the blower performance calculation.
- f. The filter element shall be designed to trap dirt on the inside so that upon changing, dirt does not fall into the machinery. Filters where dirt accumulates on the external surface of the filter shall not be permitted.

13. Base Frame / Discharge Silencer.

- a. Each package shall be supplied with one combination base frame / discharge silencer.
- b. The silencer shall be a chamber type design for maximum sound attenuation and shall not use fibrous or absorption materials of any kind. Internal absorption material has been shown to degrade and internally foul diffusers, and shall not be permitted.
- c. The silencer shall be fabricated of a single shell of pressure vessel quality steel with continuous welds.
- d. The silencer shall be subject to a pressure test for tightness and strength at a minimum of 1.65 times the maximum blower operating pressure.
- e. The silencer shall have a machined inlet connection where the discharge flange of the blower stage bolts directly to, with no intermediary pieces. Threaded connection between the compressor stage and the discharge silencer is subject to leakage and misalignment, and shall not be permitted.
- f. Discharge silencer performance losses shall be included by the blower vendor in the blower performance calculation. This is another reason why the blower accessories must be supplied by the Manufacturer of the blower stage.
- g. The base frame shall be constructed from welded carbon steel or cast iron that shall be designed to maintain alignment of the blower internal components and the drive during operation.

- h. The base frame shall be designed to resist distortion while being installed on vibration isolating mounts.
 - i. The blower Manufacturer shall supply a stainless steel grounding lug fully welded to the base.
14. Flexible Connectors.
- a. Each package shall be connected to the plant piping via flexible connector(s) located downstream of the discharge silencer.
 - b. Flexible connectors shall prevent the transmission of noise and vibrations from the blower package into the piping.
 - c. Flexible discharge connectors shall be Proco Style 240, Type EE, EPDM, with a standard ANSI flange discharge connection, rated for 300 °F at 20 psig.
15. Electric Motor.
- a. Each package shall be supplied with a WEG manufactured TEFC motor that shall operate on 460 Volts, 3 Phase, 60 Hertz current, 1800 RPM.
 - i) Torque NEMA B
 - ii) Temperature Rise Class B
 - iii) Dust tight enclosures (Severe Duty)
 - iv) Class F inverter rated insulation with Class H applied varnish
 - v) 3:1 constant torque
 - vi) All cast iron construction, including frame, end bells, conduit box and fan cover
 - vii) NPT threaded and gasketed F3 top mounted conduit box
 - viii) Copper windings
 - ix) Re-greaseable bearings, positive pressure lubrication system with automatic drawn plugs – pressure compensated (Frame sizes 254T and larger).
 - b. All frame sizes shall be NEMA standard, suitable for overhung belt drive and with the conduit box location on top of the motor. IEC frame motors shall not be allowed.
 - c. The motor shall be mounted on a pivoting base to provide automatic tensioning of the belts.
 - d. motor nominal rating after any corrections for ambient conditions shall be 10% above the maximum operating bHp.
 - e. The motor shall have a 1.15 service factor.
 - f. Blower Manufacturer shall be responsible for coordinating the starting torque requirement of the blower and the motor.
16. V-Belt Drive.
- a. Each package shall be supplied with a V-belt drive that shall be of the high capacity type, oil and heat resistant. Drive shall be designed for a minimum service factor of 1.4 times operating power (bHp), or 1.1 times the motor nameplate Hp, whichever

is larger to allow a minimum of 1.4-service factor based on the maximum blower bHp.

- b. Belt tensioning shall be automatic without the use of any devices or interaction on the part of the operator. Neither slide rails nor load-adjusting springs shall be used.
 - c. Sheaves shall be dynamically balanced regardless of the operating speed.
- 17. Belt Guard.
 - a. The belt drive shall be guarded in compliance with OSHA regulations.
 - b. Portions of the guard shall be easily removable allowing for belt inspection and replacement.
 - c. Guard material shall be perforated carbon steel.
- 18. Vibration Isolators.
 - a. Each package shall be supplied with vibration isolating feet with a minimum efficiency of 80%.
 - b. Blower manufacture shall be responsible for attenuating noise and vibration in the blower package such that no special installation base shall be required, nor shall any additional measures be required to reduce vibrations from the blower package being transmitted to the base or the piping.
- 19. Pressure Safety Valve.
 - a. Each package shall be supplied with a single pressure safety valve on the discharge side of the blower mounted downstream of the discharge silencer and upstream of the check valve.
 - b. The safety valve shall be set to protect the blower from exceeding its maximum pressure rating, and shall be sized to pass 100% of the design flow.
 - c. The safety valve shall be field adjustable, spring loaded, and have a certificate of conformity to PED.
 - d. The pressure relief valve shall be housed by the sound enclosure and shall relieve into a segmented section of the sound enclosure. Weighted relief valves inside in the enclosure shall not be permitted.
- 20. Check Valve.
 - a. Each package shall be supplied with one check valve that shall be installed on the discharge line.
 - b. The check valve shall be of the full-bore low pressure-drop, flapper type design with a steel body, and steel flap embedded in EPDM with full-contact seal.
 - c. The valve shall be removable without disturbing the piping. Pressure losses produced by the check valve shall be included in the blower performance calculation.
- 21. Instrumentation.
 - a. Each package shall be supplied with the following instrumentation:
 - i) Inlet Vacuum Gauge (4-inch Gauges) Dwyer model 2040 with 4-inch dial and scale from 0 to 40 inches of water column. Gauge to function as a filter maintenance indicator.

- ii) Inlet Vacuum Switch. Ashcroft Model B4-64-B-XFS-XBP. Type 400 pressure Switch in NEMA 4X enclosure. DUAL general purpose 15A, 110-480V switches (2) SPDT snap-acting, NOT independently adjustable. Buna-N Actuator Seal. Factory set (-20-inches of water column, decreasing). Mounting bracket. Operating range of -30 to +30-inches of water column.
 - iii) Discharge Pressure Gauge (4-inch Gauges). Aerzen Model 32-0053-02 with 4-inch dial and scale from 0 to 20 psig. The pressure gauge shall have a stainless steel case and be glycerin-filled for pulsation dampening. A pulsation snubber shall be provided.
 - iv) Discharge Pressure Switch. Ashcroft Model B4-64-V-XRN-15 psi. Type 400 pressure switch in NEMA 4X enclosure. Two (2) DUAL general purpose 15A, 110-480V switches, SPDT snap-acting, NOT independently adjustable. Viton Actuator Seal. Internal range scale and operating range of 0 to 15 psig.
 - v) Discharge Temperature Gauge / Switch (4-inch Gauges). Jumo type 8523-20-10 with a 4-inch dial and scale from 32°F to 572°F. NEMA 4 enclosure, 5A at 250 volt, SA 28 SPDT microswitch. UL & CSA approved.
 - vi) E-Stop Switch. Siemens model 52PX2V2. Mounted on the face of the blower enclosure. NEMA 4X rating. Two (2) normally closed contacts.
 - vii) Terminal Strip. The switches and motor thermostat shall be prewired to a labeled terminal junction box inside the blower enclosure.
22. Acoustical Sound Enclosure.
- a. Each package shall be supplied with a sound enclosure covering the entire blower package.
 - b. The enclosure shall provide suitable protection for outdoor installation under the specified site conditions (wind load and snow load).
 - c. The enclosure shall be designed so as to be able to install them side-by-side with all maintenance done from the front or back of the package.
 - d. Details shall be as follows:
 - i) Panels shall be made of galvanized steel sheet, powder coated in a light reflecting, blue color per RAL 5001. The skid shall be of the same color.
 - ii) Sound enclosure acoustic material shall comply with UL 94 - HF1 for fire-retardant, self-extinguishing, non-dripping materials.
 - iii) The enclosure and the blower package shall both be mounted on a skid / oil-drip pan designed for meeting environment protection standards and for easy transportation and installation.
 - iv) A grounding strap shall be installed between the blower base and the package skid to bypass any vibration isolating mounts.
 - v) Quick release panels, each less than 50 lb (as mandated by MSHA) must provide easy and quick access for routine maintenance of the blower and the package components.
 - vi) Enclosure Cooling Fan. A high efficiency blower shaft driven ventilation fan shall provide ventilation and cooling integral to the sound enclosure.

- vii) Cooling fan shall be sized for sufficient heat removal from the sound enclosure, even when the blower is operated with a VFD.
- viii) Electrical components, instrumentation and instrument connections shall not be mounted or interface with moving panels of the sound enclosure.
- ix) Both blower oil sumps shall be piped to a common fill and drain, located at the front of the package for easy maintenance. An oil level indicator shall be mounted on the outside of the enclosure, which gives an accurate oil level indication while the blower is in operation. All oil lines to be hydraulic hose with fittings. No plastic tubing with compression fittings shall be allowed.

G. Dissolved Oxygen Monitor System

1. Probe.
 - a. Type: Luminescent
 - b. Probe: Noryl and Type 316 stainless steel.
 - c. Sensor: Polybutyl Methacrylate.
 - d. Electrode to Analyzer Cable: Provide 30 feet of integral sensor cable with a quick disconnect type plug.
 - e. Temperature Range: 32°F to 122°F.
 - f. Measuring Range: 0 to 20 ppm 0 to 20 mg/L, 0 to 200% saturation.
 - g. Accuracy: < 1 ppm $\pm$ 0.1 ppm; > 1 ppm $\pm$ 0.2 ppm.
 - h. Manufacturer: Hach Company; LDO Probe, or equal.
 - i. Quantity: One (1) per basin.
2. Transmitter.
 - a. Enclosure: NEMA 4X enclosure with corrosion-resistant finish.
 - b. Power: 120 VAC w/Plug and Cord
 - c. Relays: Three SPDT contacts rated 100 to 230 Vac, 5 amp resistive maximum.
 - d. Outputs: Two analog 4-20 mA outputs, maximum impedance 500 Ohms.
 - e. Display: Graphic dot matrix LCD screen with LED backlighting
 - f. The controller shall be capable of receiving data from two separate sensors.
 - g. Manufacturer: Hach Company, Model SC200 Controller

H. ORP Monitoring System

1. ORP Probe.
 - a. The convertible style sensor shall have a Ryton® body and include a PTFE Teflon® double junction, and Viton® O-rings. The ORP sensor shall have a glass ORP electrode.
 - b. The sensor shall communicate via MODBUS® RS-485 to a Hach Model SC200 Controller.
 - c. The sensor shall be Hach Company or equal.

- d. Quantity: One (1) per basin.

I. Level Monitoring System

- 1. Level sensor with integral transmitter.
 - a. Sensor: Sensor shall have sufficient range for the application and shall be supplied with sufficient cable length for arrangement indicated. Unit shall be supplied with automatic temperature compensation.
 - b. Enclosure: NEMA 6 enclosure with corrosion-resistant finish
 - c. Power: 24 VDC loop powered
 - d. Output: 4-20 mA
 - e. Resolution: $\pm 0.5\%$ of full scale
 - f. Manufacturer: Siemens liquid level sensor
 - g. Quantity: One (1) per basin

J. Spare Parts

- 1. Provide spare parts that are identical to and interchangeable with similar parts installed.
 - a. One (1) Air Control Valves (ACVs) rebuild kit
 - b. One (1) pilot air filter assembly
 - c. One (1) solenoid
 - d. One (1) valve plug and cable assembly
 - e. One (1) relay
 - f. One (1) 5-micron pilot air filter
 - g. One (1) compressor intake air filter element per compressor provided
 - h. One (1) compressor air-oil separator filter element per compressor provided
 - i. One (1) each compressor primary/secondary element per compressor provided
 - j. One (1) set of blower V-belts per blower
 - k. One (1) blower inlet filter element per blower

PART 3 – EXECUTION

3.01 PREPARATION

- A. The Contractor shall verify that the field conditions are acceptable and the facilities are ready to receive work.
- B. The Contractor shall remove all construction debris from the interior of the reactor.
- C. The Contractor shall not apply any coating or material to the wall without written approval of the Supplier and the Engineer.
- D. The Contractor shall verify items provided by other sections of work are properly sized and located.
- E. The Contractor shall verify that the beginning of installation means they accept existing conditions.

3.02 INSTALLATION.

- A. Install items in accordance with approved shop drawings, Manufacturer's printed instructions and as indicated.

3.03 MANUFACTURER'S FIELD SERVICES.

- A. The services of a qualified Manufacturer's technical representative shall be provided for installation inspection, testing, startup and training. The system Manufacturer shall include the following site visits and days on site.

Service	Number of Trips	Number of Days/Trip
Installation Inspection and Testing	2	2
Compressor Installation Inspection and Testing	1	1
Blower Installation Inspection and Testing	1	1
Startup and Training	1	2

3.04 FIELD PERFORMANCE TESTING AND GUARANTEE.

- A. All mixer components shall be field tested with the respective basins full to the maximum water surface elevation.
- B. Exposed air piping shall be tested by the Contractor for leaks using soapy water on all joints and applying 100 psi test pressure. Buried air piping shall be tested using this method before the trench is filled. Air piping in the tanks may be tested by submersing the piping in non-potable water and pressurizing the piping to 100 psi, in lieu of using soapy water on all joints. Pressure testing requirement shall not apply to supply piping downstream from VP or pre-manufactured nozzle headers.
- C. The Contractor shall operate each mixing system at the maximum water surface elevation in the basins for a continuous period of not less than 72 hours. The Contractor shall correct and resolve all operating problems, deficiencies, etc., determined as a result of the tests.
- D. After the above testing is complete, field mixing performance testing of the installed Air Mixing System shall be performed by the Manufacturer as described below.
- Mixing performance testing shall be conducted in one (1) basin selected by Engineer.
 - All personnel and equipment necessary to conduct and supervise all testing shall be provided by the mixer Manufacturer. Engineer and Owner shall be notified of the test to witness at their option and expense.
 - Prior to performing the tests, the basin which shall be tested must have been in normal operating mode for at least two (2) days with TSS in typical operating ranges of 10,000 to 25,000 mg/L. No flow shall enter or exit the respective basin for two (2) hours prior to and during the test.
 - The compressed gas mixing system Manufacturer shall conduct total suspended solids (TSS) testing using a Cerlic TSS probe, or equal, suspended solids analyzer.
 - Testing Procedure.
 - Four horizontal-plane sample sites for the basin to be tested shall be selected by the Engineer. At each sample site, three (3) vertical samples shall be collected as follows: 24 inches from the surface, tank sidewall mid-point and 24 inches above the tank sidewall bottom. Each sample site must be a minimum of 4 feet

away from any structure within the tank. The samples for each location shall be analyzed as described above.

- b. The Coefficient of Variation (Cv) shall be determined for the sample set, excluding the maximum and minimum samples. The Cv shall be calculated by taking the resultant set of ten (10) samples as follows: $Cv = (100 \times \text{Standard Deviation of Ten Samples}) / (\text{Mean Value of Ten Samples})$.
- c. If the Cv is less than or equal to 10%, then the mixer performance shall be acceptable for that location.
- d. If the Cv is greater than 10%, then the mixer performance shall be unacceptable for that location and the Contractor and/or Manufacturer shall make all necessary improvements (at no additional cost to the Owner) and repeat the testing procedure at no additional cost to the Owner until the Cv is less than or equal to 10% for that location.

END OF SECTION

SECTION 46 76 26

ROTARY PRESS

PART 1 GENERAL

1.01 SUMMARY

- A. The dewatering unit shall consist of one (1) Rotary Press with its flocculator, along with control devices necessary to maintain an adequate proportion of flow and pressure, resulting in a uniform feed of sludge and diluted polymer to the Rotary Press.
- B. The feed sludge is pumped to the flocculator as to maintain a constant pressure at the flocculator inlet. To accomplish this, the rotating speed of the feed sludge pump shall be adjusted according to the internal pressure of the flocculator as to maintain the pressure close to the set value.
- C. The diluted polymer is pumped to the flocculator in such a way as to obtain a specified polymer-sludge dosage. The dosage is controlled by adjusting the speed of the diluted-polymer pump and is a function of the speed of the sludge pump, and a set value entered by the operator. From the flocculator, the flocculated sludge is fed into each of the channels of the Rotary Press.
- D. The channel outlet pressure is controlled by modulating a restrictor device at the cake outlet. The applied air pressure of the restrictor's actuator is controlled to maintain a constant outlet pressure.
- E. A local control cabinet is used to operate the system and to change the basic parameters.
- F. The control panel shall be CSA certified. All dewatering equipment and peripheral need to be controlled by the Rotary Press control panel for better integration.

1.02 SUBMITTALS

- A. The Supplier shall furnish to the Contractor for review, 2 copies of each Submittal. The term "Submittal" as used herein shall be understood to include installation drawings, catalog sheets and data sheets. Unless otherwise required, said Submittals shall be submitted to the Owner, at a time sufficiently early to allow review. The Supplier shall furnish the Owner the Submittals in compliance with the Section 01 33 00 Submittal Procedures of these Specifications.
- B. Format
 - 1. Transmittal shall be made accordingly to the following format.
 - a. Pages 8-1/2 x 11 inches, or 11 x 17 inches folded to fit 8 1/2 x 11-inch binder.
 - b. Three holes punched and arranged so holes do not destroy text or graphics.
 - c. Tabs for each section.
 - d. Bound in 3-ring binders.
 - e. Binders shall include the following identification on the cover.
 - 1) The text: "OPERATION AND MAINTENANCE MANUAL"

- 2) Project location.
- 3) Description of equipment or process system described in manual.
- 4) Name, phone number, and address of equipment Manufacturer or Operations and Maintenance Subcontractor.

f. Material shall be camera-ready quality (suitable to produce quality reproductions).

C. Shop Drawings and Product Data

1. Data sheets with description of the proposed equipment, size, length, type, capacity, arrangement, materials of construction, motor size, motor type and equipment weight, etc.
2. Provide a detailed list of components and accessories to be furnished within the scope of this Section. Provide catalog information, drawings and specifications for components of the equipment, showing principal dimensions, parts, materials of construction, material thickness, etc.
3. Design loadings to be transmitted to foundations or supports shall be furnished upon request.
4. Mechanical Submittals shall include at least the following.
 - a. Certified shop and erection drawings showing all important details of construction, sludge feed, washwater, high pressure air, and drainage connections, wiring diagrams, itemized motor horsepower, dimensions and anchor bolts.
 - b. Descriptive literature, bulletins, and/or catalogs of the equipment.
 - c. Data on the characteristics, features, and performance of the equipment.
 - d. The total weight of the equipment including the weight of the single largest item.
 - e. A complete total bill of materials for all equipment.
 - f. List of recommended spare parts.
 - g. List of spare parts supply with contract
5. Electrical Submittals shall include at least the following.
 - a. Electrical Schematics, panel layouts, point-to-point I/O (input/output) wiring diagrams, control panel network diagram, instrumentation sheets, and product data sheets for electrical equipment being supplied by the Rotary Press Manufacturer.
 - b. A complete total bill of materials for all equipment.

1.03 OPERATION AND MAINTENANCE (O&M)

- A. O&M Manuals shall thoroughly address all items of equipment, components, options, accessories, and ancillary devices provided with equipment components.
- B. O&M Manuals shall include the following minimum information in addition to that normally provided or required by the Manufacturer; and in addition to the specific requirements identified in Section 01 70 00 Execution and Closeout Requirements of these Specifications.
 1. Title Page
 - a. Project Name, Equipment model

- b. Manufacturer Information
- 2. Table of Contents
- 3. Equipment introduction, description of each item of equipment and system addressed in O&M Manual. Use project specific equipment name plate, tag numbers, manufacturing date.
- 4. Rotary Press installation procedure
 - a. Lifting instruction
 - b. Storage and installation recommendations
- 5. Rotary Press individual operating instructions
 - a. Principle of operation of the Rotary Press
 - 1) Process overview
 - 2) Zone(s) description
 - 3) Effect of parameters
- 6. Flocculator individual operating instructions
 - a. Flocculator Operation Instruction
 - b. Sludge sample operation
 - c. Jar testing procedure
- 7. Equipment automatic operating instructions
 - a. Recirculation Cycle
 - b. Dewatering Cycle
 - c. Wash Cycle
 - d. Shutdown sequence
 - e. Safety instruction
 - f. Recommended daily check list
 - g. Trouble shooting information (Problems, causes and solutions chart)
 - h. Polymer preparation
 - i. Filtrate sampling procedure
- 8. Maintenance instructions
 - a. Introduction and safety instructions for maintenance
 - b. Rotary Press
 - 1) Preventive maintenance
 - 2) Cleaning Exterior/Interior
 - 3) Lubrication chart and mechanical check list
 - 4) Recommended Preventive maintenance with schedule

- 5) Adjustment and Maintenance: Seals, deflector and inlet spacer
 - 6) Assembly Procedures
 - 7) Disassembly Procedures
- c. Flocculator
 - 1) Recommended Preventive maintenance with schedule
 - 2) Cleaning
 - 3) Lubrication chart and mechanical check list
 - 4) Replacement of the seals
 - 5) Assembly Procedures
 - 6) Disassembly Procedures
- 9. Main maintenance operation
 - a. For each item or product provided.
 - b. Identifying only provided options and accessories.
 - c. Listing complete model number as needed to order an exact duplicate.
- 10. Product Data as follows:
 - a. Complete technical data sheets for each item or product provided.
 - b. Identifying only provided options and accessories.
 - c. Listing complete model number as needed to order an exact duplicate.
- 11. General drawings as follows:
 - a. Showing all parts, assemblies, and sub-assemblies.
 - b. Showing arrangement and inter-relationship of all parts and equipment.
 - c. Showing controls and direction of flows.
- 12. Electrical drawings as follows:
 - a. Showing all control devices and prefabricated wiring and conduit.
 - b. Complete and accurate control schematics.
 - c. Control panel layouts.
 - d. Identifying all terminations and terminal strips.
 - e. Settings for all configuration dip switches.
 - f. Identify each different source of power. Use nomenclature specific to Project.
 - g. Listing and rating of all fuses or breakers.
- 13. A description of the functions including:
 - a. A description of the automatic cycles.
 - b. A list of all the alarms.

- c. A description of all the screens in the operator interface.
 - d. Listing of set points for all adjustable devices.
- 14. List of recommended spare parts.
- 15. List of recommended and alternate consumables and expendable such as lubricants and filters.
- 16. Clear and concise written instructions, with illustrations as required, for the following.
 - a. Normal operating procedures.
 - b. Long term storage procedures.
 - c. Adjusting and troubleshooting procedures.
- 17. Copies of all information provided as part of the approved Product Data or Shop Drawing Submittals.
- 18. A professionally prepared DVD, covering all aspects of Rotary Press operation and maintenance, including:
 - a. Press and component disassembly and re assembly, including channels, speed reducer drive, flocculator mixer, system piping, field instruments, pneumatic controls, control valves, seals, etc.
 - b. Maintenance of all dewatering system components, including flocculation system, pneumatic system, dewatering channels, control valves and control elements, such as meters, pressure regulators, pressure sensors, etc., mixers, drives and variable speed controllers.
 - c. Operational controls including pressure adjustments, press speed, sludge and polymer feed, as they relate to control and response to Operator variation.

1.04 QUALITY ASSURANCE

- A. All parts furnished shall be amply designed and constructed for the maximum stresses occurring during fabrication, erection and continuous operation.
- B. All materials shall be new and shall be of the very best quality, entirely suitable for the service to which the units are to be subjected.
- C. Exposed welds shall be ground smooth to form a neat uniform fillet without weakening the base metal.
- D. Design of all support structures, platforms and bracing shall be in accordance with AISC Standards. Structural Welding shall conform to American Welding Society Structural Code D1.1-82.
- E. Hardware requiring special tools or wrenches shall not be used.

1.05 WARRANTY

- A. The warranty period is fixed and precise, as it is for the shortest of the following described period:
 - 1. 12 months from the installation date, or
 - 2. 18 months from the delivery date or offer to deliver.
- B. This warranty only applies if the product is used as prescribed. This warranty shall be of no legal effect nor shall it be binding if the products and services are subject to improper use or are damaged as a result of an accident, modified, operated in a context that is other than the prescribed context of use, improperly maintained by you or is damaged by a product for which Fournier Industries Inc. assumes no liability. Wear parts are also not covered by this warranty.
- C. This warranty replaces and excludes all other warranties and conditions, explicit and implicit, legal and contractual, including implied warranties or conditions.
- D. All equipment and components which are part of the dewatering system are designed and selected for their application. However, equipment parts and/or material that have been manufactured by others shall have the same warranty coverage as that given to "Fournier Industries inc." and stipulated by each respective Manufacturer provided that their required preventive maintenance schedules have been strictly enforced.

PART 2 PRODUCTS

2.01 ROTARY PRESS

- A. Manufacturers
 - 1. Fournier Industries, Inc.
 - 2. Ishigaki Screw Press
- B. Being named an "Acceptable Manufacturer" does not relieve said manufacturer from meeting all requirements in this specification.
- C. General
 - 1. The Rotary Press is supplied with four (4) dewatering channels and can accommodate two future dewatering channels. Each channel has a diameter of 36 inches (900 mm). Flocculated sludge is fed at a low, constant pressure not exceeding 7 psi (48 kPa) into the channel where it is dewatered.
 - 2. The required number of channels is determined by the flow conditions, quality of the sludge, the dryness of the cake, the filtrate quality and economic, dimensional and maintenance considerations.
 - 3. A Rotary Press comprises at least the following components.
 - a. Drive System
 - b. Dewatering channels

- c. Rotary Press base
- d. Cake outlet chutes

D. Drive System

1. Speed Reducer: The speed reducer shall be foot mounted type with spiral bevel and helical gears. The speed reducer shall be fabricated according to ANSI/AGMA 6010 standard with a robust cast iron housing. The bevel gears shall have a minimum of AGMA quality of 9 and the helical gears a minimum of AGMA 11. Output shaft shall be made of steel with a minimum yield of 59,000 psi (300 MPa). Output shaft shall have a minimum diameter of 6-3/16 inches (158 mm). The speed reducer shall be mounted on a steel base epoxy painted (see section 3.1 for painting). No parts of the speed reducer, including gearbox seals shall be in direct contact with either the sludge filtrate or cake. The output seal shall be an integral part of the speed reducer housing; there shall be no bolt-on output cover to cause leakage, shaft or gear misalignment.
2. Motor: The electric motor shall be 480 volt, 3 phase, 60Hz, 1,800 rpm totally enclosed, TEFC, 20 HP (14.9 kW), "C" flange, premium efficiency, service factor 1.15, insulation "F" class, design "B". The electrical motor is directly coupled to the speed reducer.

E. Dewatering Channels

1. The dewatering channel of the Rotary Press shall be mounted on the gear reducer output shaft. Each channel shall be an independent self-contained modular unit which can be interchanged with other Rotary Presses of the same model. The low-speed shaft seal of the speed reducer shall, in no way, act as a filtrate seal for the dewatering channel. All material in direct contact with the flocculate sludge or with the cake shall be in stainless steel or plastic made.
2. Each channel shall consist of:
 - a. Filtration elements: The filtration elements shall be made of stainless steel and be hard chrome plated for wear resistance. The filtration elements shall be a non-clogging design which does not require washwater during operation. Filtering element shall be manufactured from thin stainless steel plate. Filtering element made from wire or wedge wire are not acceptable.
 - b. Scrapers: To clean the filtration elements, each channel shall be equipped with six (6) stainless steel scrapers.
 - c. Filtration wheels: The wheels shall be made of mechanically welded stainless steel ASTM A240 / SA240, Type 304L HRAP or equal. The casting shall have wall sections with a minimum thickness of 1/2" (12 mm), so designed to withstand internal pressures of up to 300 psi (2,069 kPa). The surface preparation and painting shall be as defined in Section 3.03 of this Specification. Contact surfaces for the seals shall be made from polished Type 316L stainless steel and have a surface finish from 16 to 32 RMS.
 - d. Deflector: Deflector shall be fabricated from a molybdenum disulphide-filled nylon (Nylatron).
 - e. Fiberglass gland covers, bushings and seals:

- 1) The gland covers shall be made from 1/4-inch (6 mm) thick minimum fiberglass reinforced polyester with a minimum of three (3) to six (6) layers, depending on the cover section. This cover shall be used to compress the UHMW gland cover seal between the housing and filtration wheel. The cover shall have an outlet in its lower section to drain the filtrate.
 - 2) An additional opening is made for the outside wheel washwater system connection and air bleeding device. For inspection or maintenance, an opening port is located at the rear portion of the cover to permit easy access.
 - 3) Two (2) UHMW bushings shall guide the gland cover on the filtration wheel. Sealing shall be assured by one (1) outside lip seal, four (4) O-rings: two (2) between bushings and the filtration wheel, and two (2) compressed between the gland cover and the bushing.
- f. Housing: Each housing is made from 5/8-inch (16 mm) thick epoxy painted steel. The surface in direct contact with the cake shall be stainless steel lined. Housing is supported by the filtration wheel through a set of bushing. Rotating of the housing is restricted by a torque arm, connecting the channel housing to the gear reducer base support. Each housing is interchangeable with other Rotary Presses of the same series.
- g. Wash System:
- 1) The wash system shall be provided for use as a daily cleaning of the inside of the channel(s) and the outside of the filtration wheel(s).
 - 2) One (1) wash manifold is located inside the channel at the sludge inlet. This manifold is made of a stainless steel tubing assembly, equipped with twenty-eight (28) flush type stainless steel sprinklers.
 - 3) One (1) set of two (2) manifolds (one set for each filtration wheel) consisting of four (4) sprinklers shall be located in between the filtration wheels and the gland covers. Each manifold is made of stainless steel fittings and brass flat jet sprinklers.
 - 4) For maintenance purposes, the manifold assembly is assembled to a mounting plate bolted and sealed to the gland cover. All sets of nozzles detach from the water supply using a quick disconnect system for easier maintenance. The system is easily removable from an outside access.
 - 5) The system shall be equipped with a check valve to prevent the back flow of sludge into the wash system.
 - 6) Please only provide the washing system with clean water only.
- h. Filtrate Collector: Each channel shall be equipped with a removable filtrate collector. Filtrate collector shall be made of low linear density polyethylene (LLDPE). Filtrate outlet connection shall be 7.5-inch (190.5 mm) diameter. Each filtrate collector shall include two (2) sampling ports to sample filtrate. Sampling port shall be closed by a removable plug.
- i. Filtrate Collector Manifold: Each filtrate collector shall be piped to a manifold. Manifold shall be made with 6-inch (153 mm) diameter, Schedule 80 PVC piping. Manifold outlet shall be equipped with a 90-degree elbow.

F. Rotary Press Base

1. The base shall be fabricated from bend 3/8-inch (9.5 mm) thick epoxy painted steel plate. Base shall be a close shape to optimize rigidity and spread the load evenly to the supporting floor. Anti-rotation device fixations are integrated to the base to facilitate the installation.

G. Cake Outlet Chutes

1. Every cake outlet shall have a chute with an inspection door. The chute shall be made in low linear density polyethylene (LLDPE). A hole for mounting of a cake sensor is provided for this purpose.

2.02 FLOCCULATOR AND FEED MANIFOLD

A. The Flocculator

1. Mechanical agitation using a pressurized vessel is required before the Rotary Press to assure a proper flocculation. Static mixing device or piping used as static mixer is not authorized.
2. The flocculator Model No. 05-300-900 shall be designed with a tank capacity of 17 gallons (64.3 liters) and for 100 psi (690 kPa) pressure and a maximum temperature of 140°F (60°C). The body and bolted cover shall be fabricated of epoxy painted carbon steel. The thickness of the body shall be 3/8 inches (9.5 mm). Top cover plate shall be fabricated from 1 1/4-inch (31.8 mm) epoxy-painted carbon steel. Three (3) lifting lugs shall be supplied to facilitate handling.
3. The agitator shall be variable speed and driven by a gear motor, helical type, hollow shaft, Nord Gear Model No. SK0282. Hollow shaft shall be 1-3/16 inch (30.2 mm) diameter, 4.03 to 1 ratio, 1 HP (0.75 kw) premium efficiency motor, 1,750 rpm, 3 phase, 480V, 60Hz, continuous duty, Insulation Class F, CSA, CE & UL-approved.
4. The seal at the agitator shaft and the flocculator cover shall consist of two (2) lip seal contacts with grease cavity in between. A grease fitting shall allow the cavity to be lubricated. The shaft seal wear sleeve shall be fabricated from stainless steel. The wear sleeve shall be polished to a surface finish of 16 RMS and shall be hardened by nitriding.
5. The flocculator shall have the following connections.
 - a. Sludge inlet
 - b. Sludge outlet
 - c. Pressure sensor fitting (Ref.: Subsection 2.03.C)
 - d. Washwater connection
 - e. Polymer connection
 - f. Air purge
 - g. Spare inlet 3/4 inch (19 mm)
6. The sludge inlet and outlet connections shall be 3 inches (75 mm) in diameter with machine groove to adapt Type 77 Victaulic coupling or approved equal.
7. Threaded connections for service and instrumentation shall be located on the inlet manifold of the flocculator.

8. The flocculator shall be equipped with an air breather. The air breather shall be located at the top of the flocculator and hook up to the potable water line for occasional back wash and to the drain line to collect any sludge leak. Air breather shall be made of PVC.

B. Feed Manifold

1. Piping for flocculated sludge
 - a. The piping between the flocculator and the Rotary Press shall be made of Schedule 10, Type 316 stainless steel.
 - b. The feed manifold and other accessories shall be tested in the shop at 100 psi (690 kPa) hydrostatic pressure.
2. Pipe Fittings
 - a. The pipe fittings shall be grooved end type as described below:
 - 1) On lines less than 10 feet (3 meters) long:
 - a) Style 77 Victaulic joints or approved equal
 - 2) On lines more than 10 feet (3 meters) long:
 - a) Style 07 "Zero Flex" Victaulic joints or approved equal
 - 3) Flange-to-flange joints:
 - a) Style 741 "Vic-flange" or approved equal
 - 4) For butt or field adjust joint coupling:
 - a) Victaulic style 99 "Roust-A-Bout" or approved equal
3. Valves and Accessories
 - a. All valve(s) shall be compatible with the nominal operating pressures of the different systems and shall be designed to resist the operating temperatures and the contained fluids. The valves shall be of equal diameter as the piping, except where indicated otherwise.
 - b. Automatic Sludge feeding and recirculation valve: Two (2) pneumatically-actuated valves shall be installed on the sludge line between the Rotary Press and the flocculator. The valve shall meet the following characteristics.
 - 1) Valve
 - a) Type: Two-way ball type; Full port
 - b) Size Diameter: 3 inches (76.2 mm)
 - c) End Connection: ANSI 125# Flanged
 - d) Body Material and Facing: Painted Cast Iron
 - e) Ball Material: Ductile iron/ Teflon fuse ball
 - f) Shaft: Stainless Steel
 - g) Seat Type: RPTFE
 - h) Manufacturer: Quality Certified Valve, American Valve, Sure Flow or approved equal
 - 2) Actuator
 - a) Type: Pneumatic double acting (2-pistons design on geared shaft)
 - b) Nominal torque at 81 psi (560 kPa): 2,390 in-lb (270 Nm)
 - c) Manufacturer: FESTO or approved equal

- 3) Position Indicator
 - a) Type: Visual position switches
 - b) Switches: SPDT
 - c) Protection: Watertight, IP67
 - d) Manufacturer: FESTO or approved equal
- 4) Sludge feed and recirculation valves shall be piloted by solenoid valve located in the Rotary Press Junction Box (ref. section 4.3.6). The valve body shall be made of anodized die cast aluminum and shall have an insulation rated IP65. The working pressure shall be in the range of 36 to 116 psi (248 to 800 kPa). The solenoid valve with manual override shall be 24 VDC. Solenoid valve shall be Festo Model No. VMPA1-M1H-M-PI or approved equal.
- c. Channel Isolating valve: At the inlet of each channel, a shut-off valve shall be supplied. The valve shall meet the following characteristics.
 - 1) Valve
 - a) Type:..... Ball type; Full port
 - b) Size Diameter: 3 inches (76.2 mm)
 - c) End Connection: ANSI 125 lb Flanged
 - d) Body Material and Facing: Painted cast iron
 - e) Ball material: Ductile iron/ Teflon fuse ball
 - f) Shaft: Stainless steel
 - g) Seat Type:..... RPTFE
 - h) Manufacturers:..... Quality Certified Valve, American Valve, Sure Flow or approved equal
 - 2) Actuator
 - a) Type:..... Lever
- d. Channel Washwater valve: For automatic control purposes, a pneumatic actuator shall be installed to control the washwater valve to each individual channel. The valve shall meet the following characteristics.
 - 1) Valve
 - a) Type:..... Ball type; Full port
 - b) Size Diameter: 1-inch (25.4 mm)
 - c) Body Material and Facing: Type 316 stainless steel
 - d) Maximum pressure: 1,000 psi (6.9 MPa)
 - e) Manufacturer: C.F.F. Model No. SS-3DM or approved equal
 - 2) Actuator
 - a) Type:..... Pneumatic spring return type; Aluminum anodized body
 - b) Manufacturer: Festo Model No. VMPA1-M1H-M-PI or approved equal
 - 3) Washwater valve shall be piloted by solenoid valve located in the Rotary Press Junction Box (Ref. Section 4.3.6). The valve body shall be made of anodized die cast aluminum and shall have an insulation rated IP65. The working pressure shall be in the range of 36 to 116 psi (248 to 800 kPa). The solenoid valve with manual override shall be 24 VDC. Solenoid valve shall be Festo Model No. VMPA1-M1H-M-PI or approved equal.

- e. Other Valves: All other valves other than the one above shall meet the following characteristics.
 - 1) Valve
 - a) Type:.....Ball type; Full port
 - b) Size Diameter: As required
 - c) Body Material and Facing: Type 316 stainless steel
 - d) Seat Material: PTFE
 - e) Manufacturers:.....Quality Certified Valve, American Valve, C.F.F. Trueline, H&P or approved equal
 - 2) Actuator
 - a) Type:.....Lever
4. Polymer Check Valve
 - a. A stainless steel 1-inch (25.4 mm) NPT check valve shall be installed on the polymer line to prevent sludge from entering the polymer feed line. The check valve shall start to open at 0.5 psig (3.4 kPa) and shall be fully opened at 1.0 psig (6.8 kPa). The valve shall be spring assisted for silent closing and minimizing the effect of water hammer. The valve temperature limit shall be 20°F to 400°F (-29°C to 204°C). The model shall be IFC Model No. SC600TSSSSM.
5. Flocculated Sludge Sampler
 - a. A flocculated sludge sampler shall be supplied. The device shall consist of a transparent PVC tube to inspect the texture of the flocculated sludge. A 3/4-inch (19 mm) vent and 2-inch (50 mm) sludge inlet and sludge draining valves shall allow filling and draining the sampler without dismantling or adding any pipes, tubes or plugs. A 3/4-inch (19 mm) vent shall also be installed for wash purpose. The sampler shall be easily removable for maintenance.
6. Washwater Pressure Gauge
 - a. A pressure gauge shall be installed at the flocculator on the washwater line. The pressure gauge shall be a 2-1/2 inches (63.5 mm), liquid filled. The scale shall be 0 to 160 psi (0 to 1.1 MPa).

2.03 FLOWMETERS

A. Sludge Flowmeter

1. The sludge flowmeter shall be installed at the flocculator inlet. The instrument shall meet the following Specifications.
 - a. Type: Electromagnetic
 - b. Linearity error: $\pm 0.5\%$
 - c. Diameter/measuring range: 3-inch (75mm); 24 to 800 gpm (5.5 to 181.6 m³/h)
 - d. Process temperature: -4°F to 176°F (-20 °C to 80°C)
 - e. Electrical connection: 1/2 inch NPT
 - f. Process connection Flange type

- g. Display/operation: Two line display with backlit / push button
- h. Output signal: 4-20 mA
- i. CSA/FM approval class: Class 1 Division 2
- j. Liner material: Polyurethane
- k. Electrode material: Type 316L stainless steel
- l. Protection: IP67/NEMA 4X, IP68/NEMA 6P
- m. Company: Endress & Hauser
- n. Series: 10W or approved equal

B. Polymer Flowmeter

1. The polymer flowmeter shall be installed at the flocculator inlet. The instrument shall meet the following Specifications.
 - a. Type: Electromagnetic
 - b. Linearity error: $\pm 0.5\%$
 - c. Diameter/measuring range: 1-inch; 5 to 80 gpm (1.1 to 18.1 m³/h)
 - d. Process temperature: -40°F to 266°F (-40°C to 130°C)
 - e. Electrical connection: 1/2 inch NPT
 - f. Process connection: Flange type
 - g. Display/operation: Two line display with backlit / push button
 - h. Output signal: 4-20 mA
 - i. CSA/FM approval class: Class 1 Division 2
 - j. Liner material: PTFE
 - k. Electrode material: Type 316L stainless steel
 - l. Protection: IP67/NEMA 4X, IP68/NEMA 6P
 - m. Company: Endress & Hauser
 - n. Series: 10P or approved equal

C. Inlet Pressure Gauge and Transmitter

1. The inlet pressure gauge and transmitter shall be installed at the flocculator inlet. The instrument shall meet the following Specifications.
 - a. Type: Digital pressure transducer, capacitive, ceramic
 - b. Linearity error: $\pm 0.075\%$
 - c. Process temperature: - 4°F to 257°F (-20°C to 125°C)
 - d. Operating pressure range: 0 to 30 psi (0 to 207 kPa)
 - e. Proof pressure: 270 psi (1.8 MPa)

(Without any damage to the transducer)

- f. Electrical connection: 1/2 inch NPT
- g. Calibration: 0 to 30 psi (0 to 207 kPa)
- h. Output: 4-20 mA, with Hart Communication, 2 lines LCD display
- i. Process connection: 1/2 inch NPT
- j. Protection: Class I, II, III Division 1
- k. Diaphragm material: Ceramic
- l. Company: Endress & Hauser
- m. Series: PMC71

D. Outlet Pressure Control

- 1. Cake outlet pressure shall be controlled by air pressure on the bellows actuating the vertical restrictor.
- 2. Adjustable airline pressure regulator shall be used to control the outlet pressure. Each channel shall have its own in line air regulator. Regulator shall be relieving type, pressure range 0 to 100 psig (0 to 690 kPa), 1/4-inch port, with 150 psig (1 MPa) pressure gage. Regulator shall be Festo Model No. MS4N-LR-1/4-D6-AS or approved equal.
- 3. For automation purposes, Electro-pneumatic transducer shall be supplied with the control system and shall be Festo Model No. VPPE-3-1-1/8-6-420-E1 or approved equal.

E. Cake Sensing

- 1. Each channel shall have a cake sensor mounted on the outlet chute cover. For easy maintenance, the sensor shall be equipped with a quick connector. Sensor shall be Schneider Electric Model No. XT218A1PCM12 or approved equal

F. Wash water Pressure Switch

- 1. A pressure switch shall be installed on the washwater line at the flocculator. The pressure switch shall be 1/4 inch NPT, SPST/NO. The switch shall cover an adjustable range of 30 to 120 psi (207 to 827 kPa). The switch shall be shop calibrated at 60 psi (414 kPa) and sealed. The dry contact of the switch shall be used to produce a low pressure alarm on the operator interface.

2.04 PROCESS CONTROL CABINETS

A. Prewired Control Cabinet

- 1. Prewired control with connection to field devices and field wiring through terminal strips, in a NEMA 12 enclosure shall be provided. The control cabinet shall operate on 480 volts, 3 phase, 60 Hz,. The control cabinet shall include the following.
 - a. Back-panel mounted components and devices consisting of (but not limited to) the following.

- 1) Main fused disconnect switch
 - 2) Circuit breakers for PLC, HMI and others control devices
 - 3) Line reactor
 - 4) Variable frequency drive (VFD)
 - 5) Programmable logic controller (PLC)
 - 6) Filter and surge protective device for control voltage
 - 7) DC power supply
 - 8) Relay
 - 9) Safety relay
 - 10) LAN modem (Internet communication)
2. Door mounted components consisting of (but not limited to) the following.
 - a. Power warning alert indicator
 - b. Operating handle for main fused disconnect switch
 - c. Emergency stop push button
 - d. Human machine interface (HMI)
 3. Control cabinet air conditioning system shall be supplied if required by the heat load calculation vs room temperature. If required, the air conditioning system shall be Hoffman Proair Harsh Environment CR23 Series or approved equal.

B. Programmable Logic Controller (PLC)

1. A programmable logic controller shall be used to control the Rotary Press and the related equipment. PLC shall have Ethernet/IP communication to communicate with the VFD, HMI and the plant network. The PLC shall have the following Specifications.

Processor unit	CompactLogix 5370 series (L1X series), including 16 in sink/16 out source Communication ports: 2 Ethernet/IP, 1 USB Memory card type: SD Nominal input power: 24 VDC Input power range: 10 to 28.8 VDC Operating temperature: -4°F to 140°F (-20°C to 60°C)
Additional I/O modules	Point I/O (1734 series)
Analog inputs	24 VDC Analog current input (0-20, 4-20mA selectable), single ended, non-isolated Resolution: 16 bits Absolute accuracy: 0.1% Full scale at 77°F (25°C) Operating temperature: -4°F to 131°F (-20°C to 55°C) Data format: Signed integer Maximum overload: Fault protected to 28.8 VDC
Analog outputs	24 VDC Analog current input (0-20, 4-20mA selectable), single

	ended, non-isolated Resolution: 16 bits Absolute accuracy: 0.1% Full scale at 77°F (25°C) Operating temperature: -4°F to 131°F (-20°C to 55°C) Data format: Signed integer
Discrete inputs	24V DC discrete sink input Minimum voltage on-state (Nominal): 10V VDC (24 VDC) Minimum voltage off-state: 5 VDC Field power nominal voltage: 24 VDC Field power voltage range: 10 to 28.8 VDC Operating temperature: -4°F to 131°F (-20°C to 55°C)
Discrete outputs	24V DC discrete source output Minimum voltage on-state (Nominal): 10 VDC (24 VDC) Output signal delay: Off to On 0.1 ms On to Off 0.1 ms Field power nominal voltage: 24V VDC Field power voltage range: 10 to 28.8 VDC Output current rating: 1.0A per output, not to exceed 3.0A per module Operating temperature: -4°F to 131°F (-20°C to 55°C)
Certification	cULus-Listed Class 1 Division 2
Company	Allen-Bradley
Series	CompactLogix

C. Human Machine Interface (HMI)

1. A human machine interface shall be used to operate the Rotary Press and the related equipment.
2. Touchscreen operator interface. The touchscreen operator interface shall have the following Specifications.

Display type and size	TFT Color LCD; 5.7 inches (14.5 cm)
Graphic display resolution	600 x 480 (VGA)
Display colors	18-bit Colors
Touch screen	Analog resistive
Operating temperature	32°F to 131°F (0°C to 55°C)
Communication ports	Ethernet, USB
Programming memory	512 MB Flash EPROM
Memory card type	SD
Input voltage (power consumption)	24 VDC (35 W or less)
Certification	CE, cULus Listed Class 1 Division 2
Protection	IP54, IP66, NEMA 12/13/4X indoor use only
Company	Allen-Bradley
Model	2711P series (PanelView Plus 7)

D. Variable Frequency Drive (VFD)

1. Variable frequency drive shall be used to control the speed of the Rotary Press and the flocculator. VFD shall have overload protection and ramp regulation capability. Configuration and programming shall be done via a keypad. Run command, status and speed control shall be handle using communication network (VFD Ethernet/IP or RS485/DSI). As per Owner requirement, VFD shall be powered as per power inlet described in Section 4.3.1 of this Specification. Output shall be 480 VAC, 0 to60Hz. The VFD shall have the following Specifications.

Voltage input	As per Control cabinet Voltage input
Output voltage	Adjustable 0V to rated motor voltage
Input frequency variation	47 to 63 Hz
Communication	Integral RS485 with modbus RTU/DSI, Ethernet/IP
Operating temperature	-4 to 122°F (-20 to 50°C)
Certification	CE, cULus Listed
Protection	IP20 NEMA/Open
Company	Allen-Bradley
Model	PowerFlex 52X Series
Rotary Press rating	As per motor requirement
Flocculator rating	1 HP (0.75 kW)

E. LAN Modem (Internet Communication)

1. A LAN modem is used for remote access in case of programming change needs and troubleshooting. This modem uses common internet as communication link. The LAN modem shall have the following Specifications.

Power supply (consumption)	12 to 24 VDC +/-20% (10W)
Communication port	1 SubD9 serial port RS232 (RS485 not isolated) 1 RJ45 Ethernet 10/100 base Tx
Operating temperature	-4°F to 158°F (-20°C to 70°C)
Certification	CE, cCSAus
Company	Ewon
Model	Cosy 141

F. Rotary Press Junction Box

1. A pre-wired NEMA 4X FRP enclosure junction box shall be installed on the rear of the Rotary Press gearbox. Wash valves and cake detection sensor shall be routed to this junction box and connected to terminal blocks. The Rotary Press junction box shall include, but not limited to, the following components.
 - a. I/P converter
 - b. Air filter and regulator
 - c. Solenoid valve for pneumatic control of sludge feeding and recirculation valve

- d. Solenoid valve for pneumatic control of washwater valve
- 2. To ensure proper air quality and inlet pressure control to system, an air regulator and an air filter are furnished and installed on the air inlet supply of the Rotary Press junction cabinet. The air regulator and air filter shall be rated for air purity class 3.7 per DIN ISO 8573-1, high efficiency general purpose protection for a particle removal down to 5 microns, including water and oil aerosols. 1/4 inch NPT type connection, fully automated drain, maximum pressure 175 psi, operating temperature between 35°F and 140°F (2°C and 60°C), an integrated air regulator shall include a manometer, range 0-175 psi with lockable Rotary knob. Air regulator shall be Festo Model No. MS4N-LFR-1/4-D7-CRV-AS or approved equal.

G. Emergency Stop Push Button

- 1. An emergency stop push button shall be installed in front of the Rotary Press and wired to the junction box.

2.05 PROGRAMMING

A. Control

- 1. Process parameters and control shall be accessible to the pre-program PLC via operator interface. The operator shall have access to the following.
 - a. Sludge inlet pressure
 - b. Outlet pressure control
 - c. Polymer/Sludge ratio
 - d. Rotary Press rotating speed
 - e. Flocculator agitator speed
 - f. Manual control of each equipment

B. Protection and alarms

- 1. Programming shall include the following protection/alarm.
 - a. High inlet pressure, stop the dewatering system
 - b. Zero flow on sludge input flow, stop the dewatering system
 - c. Cake flush, stop the dewatering system
 - d. Preventive maintenance notice, alarm only
 - e. Low washwater, alarm only
 - f. Low air pressure, stop the dewatering system
 - g. Any motor did not start, stop the dewatering system
- 2. Programming shall include at the minimum the following alarms.
 - a. Rotary Press faulted
 - b. Rotary Press did not start

- c. Flocculator faulted
- d. Flocculator did not start
- e. Sludge pump faulted
- f. Sludge pump did not start
- g. Sludge pump low flow
- h. Polymer pump faulted
- i. Polymer pump did not start
- j. High inlet pressure
- k. Cake flush
- l. Low air pressure
- m. Low washwater pressure
- n. Preventive maintenance warning

C. Operator Interface Screens

1. The operator interface shall be built to be “user-friendly” to the Operator. The following screen page shall be available to the Operator.
 - a. Menu page
 - b. Cycle start-stop page
 - c. Parameter page
 - d. Sludge pump control loop page
 - e. Rotary Press manual operation page
 - f. Preventive maintenance advise page

D. Standard Features

1. System programming to incorporate the following features as standard control.
 - a. Individual or grouped channel wash selection (for optimal wash depending on the water supply)
 - b. Automatic system start at selected time of the day
 - c. Automatic adjustable delayed system stop

2.06 CONVEYOR SYSTEM

A. General

1. These Specifications shall be considered as minimum requirements. The Contractor or equipment Supplier shall add such additional features as are necessary for satisfactory operation and functioning of the conveying equipment.

2. Structural design shall be in accordance with American Institute of Steel Construction AISC Standards.
3. Except as otherwise indicated, welding shall comply with ANSI/AWWA D100 and AWWA C206, and the following specifications.
 - a. Welding shall be by the metal-arc method or gas-shielded arc method described in the American Welding Society's "Welding Handbook" as supplemented by other AWS standards. Welding shall conform to American Welding Society Structural Code D.1.1-82. Qualification of welders shall comply with AWS Standard AWS D1.198.
 - b. During assembly and welding the component parts shall be clamped, supported and restrained to minimize distortion and for control of dimensions. Weld reinforcement shall comply with the AWS code. Upon completion of welding, weld splatter, flux, slag and burrs left by attachments shall be removed. Welds shall be repaired to produce a workmanlike appearance with uniform weld contours and dimensions. Sharp corners on material that is to be painted or coated shall be ground to a minimum of 1/32 inch on the flat.
4. Material type, thicknesses and dimensions shall conform to the screw conveyor schedule requirements unless otherwise specified, or required for structural considerations.
5. The screw conveyor system shall transport mechanically dewatered wastewater treatment plant sludge from the Rotary Press to the final discharge point area as shown on the Contract Drawings.
6. The screw conveyors system shall be provided complete with all necessary components, drives, motors, instrumentation, controls, ancillary items and supports, except as otherwise shown or specified herein.
7. The design of the sludge conveying and system shall be based upon the Contract Drawings, these Specifications and the Manufacturer's experience with existing systems of similar sizes, capacities and handling material with similar characteristics.
8. The Contract Drawings, and this Section, provide equipment descriptions, minimum requirements and mandatory features of the equipment to be furnished. It is the Manufacturer's responsibility to design and furnish the equipment complete in all details, performance, and reliability meeting the requirements and intent of the Contract Drawings and these Specifications.
9. The equipment shall be furnished complete with all accessories, special tools, and other appurtenances as specified herein or as may be required for a satisfactory installation.

B. Reference Specifications, Codes and Standards

1. The screw conveyors shall be designed and manufactured in accordance with the following listed Standards and Specifications, including applicable addenda in effect as of the date of bid submission. They shall be considered an integral part of this specification and shall govern the design, fabrication, testing and inspection of equipment, except as otherwise shown or specified herein.
 - a. American Gear Manufacturers Association (AGMA)
 - b. American Welding Society

- c. Conveyor Equipment Manufacturers Association (CEMA)
- d. National Electrical Manufacturers Association (NEMA)
- e. Anti-Friction Bearing Manufacturers Association (AFBMA)
- f. American National Standards Institute (ANSI)
- g. National Fire Protection Association (NFPA)
- h. American Society for Testing Materials (ASTM)
- i. Joint Industrial Council (JIC)
- j. American Society of Mechanical Engineers (ASME)
- k. Underwriters Laboratories Inc. (UL)
- l. Institute of Electrical and Electronic Engineers (IEEE)
- m. American Institute of Steel Construction (AISC)

C. Conveyor Troughs

1. Horizontal and inclined conveyor trough bodies shall be “U” type for horizontal conveyors and “O” type for inclined conveyors with trough dimensions conforming to the requirements of CEMA Standard 300, with exceptions as noted herein. The conveyor trough bodies shall be rolled to shape with both side flanges formed with the trough body. Trough end flanges, welded to each trough section, shall be provided for joining adjacent sections or connecting trough end plates to the trough sections. Each conveyors trough sections must not exceed 8 feet (96 inches) from flange to flange.
2. Conveyor troughs shall be equipped with a wear liner across the entire inside length. The wear liner shall be fabricated of high density UHMW polyethylene. The wear liner shall be provided in 4-foot long sections for ease of replacement. The wear liner shall be held in place using clips welded to the inside of the trough. Clips shall be placed away from the conveyor spiral path.
3. Each conveyor shall be equipped with a drainage valve at its lower end. The drainage valves must be stainless steel ball valve of 2 inches in diameter.
4. Conveyor troughs for shaftless screw conveyors shall be furnished with anti-floatation devices. Anti-floatation devices shall be installed at a minimum distance of every sixteen (16) feet of conveyor length.

D. Conveyor Covers (U Shape Only)

1. A sectional plate shall cover the entire trough, with exception of the inlet chute connections located. Cover segments at inlet chute connections shall extend, on each side, beyond the inlet chute connection and shall be bolted in place. Each cover section shall be not greater than 6-feet in length. The cover segments shall be arranged so that the trough flange and a trough stiffener provide support to each edge.
2. The covers open for maintenance and cleaning purposes. The cover shall be bolted.

E. Conveyor End Plates

1. End plates shall be bolted to the trough end flange. End plates shall be designed to support the drives, bearings and gear reduction assembly.
2. Where shafts penetrate the end plates, the end plate shall be provided to accommodate the stuffing box provided.

F. Conveyor Chutes

1. Trough inlet and discharge chutes shall be bolted to the adjoining equipment as shown on the Contract Drawings. Inlet and discharge chutes shall be supplied with reinforced rectangular or circular flanges.

G. Conveyor Drive Train Equipment

1. The conveyor drive train equipment shall transmit power to the conveyor drive shaft using a shaft mounted speed reducer connected to an electric motor. Drive units shall be rigidly supported to avoid all visible "wobble" movement under any operating conditions. Any leakage coming from the trough passing through the shaft seal shall leak through the adapter end plate to atmosphere rather than into the gear motor.
2. Drive Shaft Assembly
 - a. The drive end assembly shall consist of the following components.
 - 1) Drive Shaft
 - 2) Seal plate
 - 3) Hollow Shaft Gear Reducer
 - b. The tail end shall consist of the following components
 - 1) Zero Speed Sensor
 - c. Drive shafts for the shaftless screw conveyors are to be complete with mating connections appropriate for mating to the shaftless screw assembly. The drive shall be of adequate diameter to handle all radial, thrust and torsion loads. The drive shafts shall be mounted to the shaftless spiral by a flanged connection.
3. Drive Motor
 - a. Drive motors shall be of the high starting torque (NEMA B or C design), TEFC, squirrel cage, AC induction type suitable for continuous severe duty service. The motor shall have Class F, MG 1 Part 31.4.4.2 Inverter Duty insulation, and a Class B temperature rise at 40°C ambient temperature. The drive motor shall be high efficiency with a 1.15 service factor.
 - b. The drive motor shall operate at 1800 rpm nominal speed and be sized to operate without overloading when the screw conveyor is operating at, or below, the design capacity. The minimum motor horsepower shall be as specified on the conveyor schedule elsewhere herein.
4. Speed Reducer
 - a. The speed reducer shall be a gearmotor enclosed shaft mount, type unit with a double or triple reduction ratio, as may be required. The speed reducer shall mount directly on the

drive shaft and utilize a standard CEMA mounting to support structure. We highly recommend Screw Conveyor Package design flange from Nord Gear Corp.

- b. The speed reducer sealing system shall be a Quadrilip system that has four components for sealing lubricant inside and contaminants outside of the speed reducer. The system must include a double lip seal, a single lip seal and grease pack barrier (grease lip). The sealing system shall also include diverting ports to avoid any possibilities of contamination to the gear reducer oil, even if the first seals broke down.
- c. The speed reducer housing shall be constructed of 1-piece corrosion resistant gray cast iron torsional stiff. All housings bore and mounting faces shall be machined in one step to produce extremely precise tolerances. This ensures accurate positioning of gear teeth, bearings, and seals and a longer life of all components.
- d. All speed reducer gearing shall be of helical design. High speed gears shall be ground and low speed gear skive hobbed. The gears' hardness shall be a minimum of 58 HRC. With an overload capacity of 275%.
- e. The speed reducer bearings shall be ball or tapered roller type and provide a 50,000-hour B10 life at the expected design loading rate. All seals shall be double lip, spring-loaded type and made of nitrile rubber. Shaft seals shall be quadrilips two (2) nitrile seals, which consists of two (2) sealing lips, a trash guard lip and a grease chamber between the seals.
- f. The speed reducer shall be manufactured to Quality Class 8 per AGMA Standard 6001-C88, minimum. The gear reducer shall be selected for AGMA Class 11 service with a 1.4 service factor based on motor nameplate horsepower.
- g. The speed reducer shall be as manufactured by Nord Gear Corp., or approved equal.

H. Conveyor Supports

- 1. The conveyor troughs shall be supported using saddle type supports shaped to the profile of the troughs and extending to a common fixed distance below the centerline of the screw. Saddle type supports shall be located not greater than 16-feet center-to-center. Separate support points shall be provided (when possible) under the drive end and tail end assemblies. These supports are to be bolted to the trough flange.
- 2. Trough thickness shall be design to maintain through shape under loading. Transverse stiffeners shall not be used in order to allow easy maintenance of the UHMW liner and for the flight maintenance.
- 3. Support loadings are to be based on a completely filled trough, weight of the conveyor and the dynamic loading when operating.
- 4. The Contractor shall coordinate with the conveyor equipment Supplier support locations with the facility structural constraints. Access to other process systems and equipment shall not be restricted by the conveyor supports.
- 5. Each conveyor shall be field shimmed as required to conform to the Manufacturer's installation tolerances.

I. Shaftless Screw Assemblies

1. The shaftless screw flights shall be cold rolled spirals fabricated from high strength carbon spring steel bars with a minimum tensile strength of 100,000 psi and a minimum Brinell hardness of 200 BHN.
2. Shaftless screw conveyor spiral flights shall be formed in a forming machine to the diameter and pitch required. Each formed section shall be factory welded into full lengths. Where the length of the conveyor precludes shipping, sub-sections of flighting shall be divided into maximum shipping lengths and welded together in the field.
3. Field splicing of flighting sections shall be by full penetration welds done in strict accordance with the Manufacturer's instructions using AWS certified welders.
4. Spiral flighting shall be connected to the drive shaft using a flanged connection plate that shall be welded to the spiral on one end. Transition between the flighting and connection flange shall be smooth and fabricated to the tolerances listed below. The drive shaft shall have a matching mating flange and shall be bolted to the flight connection plate.

J. Zero Speed Switches

1. Motion failure alarm unit shall equip each conveyor. The motion sensor shall be a non-contacting type probe. This probe shall be able to read screw rotation outside of the process, by reading disruption of the magnetic field by the ferrous target (flight).
2. The electronic unit shall operate on 120 volts AC power supply and shall be rated NEMA 4X or IP67. The probe signal shall be relay interconnected with a PLC digital input.
3. The zero speed sensors shall be located at the opposite end of drive. The PLC is always counting pulses, without any pulse count a PLC digital output shall be activated for an alarm or shall stop the whole system. Relay switch contacts shall be rated 120 VAC and interlocked with MCC motor starter.
4. Zero speed detection switches shall be Siemens model SITRANS WM100, or equal.

K. Conveyors Control

1. Conveyors shall be controlled by the Rotary Press PLC and operator interface.

2.07 POLYMER SYSTEM

A. General

1. Emulsion Polymer Make-Up System (Liquid Polymer System): The polymer system shall be capable of effectively activating and fully blending a homogenous final polymer solution from neat polymers with a 0.1% to 0.5% concentration with an active content from 40% to 55%.
2. The support frame, brackets, ball valves are made of 304 stainless steel. The water piping shall be made of HDPE plastic. The inlet & outlet of neat polymer is blue polyethylene flexible hose.

B. Water Pressure Regulator (Relief Valve)

1. Clean or filtered water is required at a minimum pressure of 45 psi. The water pressure must not exceed 100 psi. Supplied pressure is controlled by a water pressure reducing valve and

shall be adjusted to 40 psi. A pressure gauge, fixed on the water line, shall display real time pressure while the system is under operation.

C. Proportional Valve (Dilution Water Flow)

1. During the process, the water flow is controlled by a proportional valve, which is an assembly consisting of a ball valve and a positioner. The positioner shall be supplied by a minimum air pressure of 90 psi. The operational flow range for this valve is selected from 0.1 to 20 gpm (0.4 to 75 L/hour) and shall be measured by a flow meter installed on the flocculator (already provided with Rotary Press). The regulation of this valve shall be based on the ratio Polymer Ratio vs. Sludge, calculated from Rotary Press PLC.
2. Requires 24 VDC power and 4-20 mA signal for control.

D. Chemical Metering Pump (Polymer Dosing)

1. The pump is a peristaltic type. The flow rate range shall be 0.001–7.93 gallon/hour (0.1–500 mL/minute), and up to 7 bar (100 psi) RMS pressure. A polymer strainer is included and mounted on the inlet suction side of the pump. The control of this pump shall be based on Water Flow vs. Final Concentration, calculated from the Rotary Press PLC.
2. The pump is available 120VAC, 50/60 Hz or 24 VDC power, and the control is 4-20 mA.

E. Static Mixer (Mixing Chamber)

1. The polymer and the water are injected and mixed inside the static mixer. The energy needed for mixing comes from a loss in pressure as water flow through the static mixer. At the outlet of this motionless mixer, the final solution at the accurate concentration is created.

F. Junction Box (NEMA 4X)

1. The simple construction of these enclosures makes them durable in corrosive environments and have a secure seal. The pump & proportional valves are landed on terminal block. The electrical supply can come from a standard electrical outlet 120VAC or from the Fournier control panel. A power supply 120VAC / 24VDC is included. The control is assumed by a remote or an existing PLC & HMI. It is recommended to have this system controlled by Rotary Press PLC and HMI for full integration.

G. Control and Maintenance

1. The control of the make-up system is provided by the Rotary Press control panel or existing PLC and HMI. The HMI allows the user to manually change the concentration and percent active parameters of the neat polymer as well as the desired final concentration of solution. The HMI allows for the components to be operated in Hand mode as well as to function in Auto (remote) mode, which uses the control signal from the Rotary Press PLC.
2. All components are modular, no special tool required and easily accessed.

H. Spare Parts

1. One (1) set of Metering Pump Head replacement kit (no special tool required)

I. Components List

Item	Description	Manufacturer
1	Base Frame	Fournier Industries
3 to 5	Bracket Support	Fournier Industries
300	Dosing Pump	Watson-Marlow
301	Ball Valve 1/2 inch	McMaster
302	Static Mixer	Koflo
303	Pressure Regulator	Watts
304	Strainer 1/2 inch	McMaster
305	Pressure Gauges 0 to 100 psi	McMaster
306	Valve and Actuator (Proportional Valve)	Festo
308	Ball Valve 1/2 inch	McMaster
309	3-Ways Ball Valve 1/2 inch	McMaster
324	Hose 1/2 inch	McMaster
325	Junction Box, 10 X 10 X 8	Hoffman

2.08 SLUDGE PUMP SYSTEM

A. General

1. The equipment covered by these Specifications shall be of standard units of proven ability as manufactured by reputable concerns having long experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed as shown on the Contract Drawings.
2. The Rotary Lobe Pump shall be provided by the Rotary Press Manufacturer in a part of the Rotary Press package. The pump shall be VFD controlled by the Rotary Press located in the Rotary Press control panel.
3. All equipment shall be designed and built for 24-hour continuous service at any and all points within the specified range of operation, without overheating, without cavitation, and without excessive vibration or strain.
4. The pumping units required under this section shall be complete. All parts shall be so designed and proportioned as to have liberal strength, stability, and stiffness and to be especially adapted for the service to be performed. Ample room for inspection, repairs and adjustment shall be provided.
5. Stainless steel nameplates stating the name of the Manufacturer, the pump serial number and material code and all other pertinent data shall be attached to each pump and motor.
6. All working parts of the pumps and motors, such as bearings, wearing rings, shaft, sleeves, etc., shall be standard dimensions built to limit gauges or formed to templates, such that

parts shall be interchangeable between like units and such that the Owner may, at any time in the future, obtain replacement and repair parts for those furnished in the original machines.

7. The nameplate ratings of the motors shall not be exceeded, nor shall the design service factor be reduced when the pump is operating at any point on its characteristic curve at maximum speed.
8. Mechanical equipment, including drives and electric motors shall be supplied and installed in accordance with applicable OSHA regulations. The noise level of motors, unless otherwise noted, shall not exceed 85 dBA, measured 3 feet (1 meter) from the unit under free field conditions while operating on utility power.
9. All lubrication fittings shall be brought to the outside of all equipment so that they are readily accessible from the outside without the necessity of removing covers, plates, housings, or guards.
10. Warranty: Rotary Lobe Pumps supplied under this section shall be warranted to be free from defects in workmanship, design and materials for a period of one (1) year from shipment.

B. Pumps

1. The Rotary Lobe Pumps shall be designed to be abrasion resistant for applications in wastewater treatment plants. The pump shall have a minimum displacement of 13.2 gallon / 100 revolutions.
2. The ratio of the axial length of the lobe as compared to the lobe diameter (length/diameter) shall not exceed 1.0.
3. The pumps shall be of the positive displacement, Rotary lobe type, designed to pump wastewater sludge as manufactured by Boerger, or approved equal.
4. All fluid-wetted parts including the mechanical seal shall be replaceable through the quick release front cover without disassembly of coupling, drive unit or the pipe system.
5. The pumps shall be designed to temporarily run dry and to operate in either direction. Oil-quench for protection of the mechanical seal is mandatory. Seal water flush systems are not acceptable.
6. The pumps shall be constructed with an oil-filled intermediate chamber between the pump casing and the gearbox with the following functions.
 - a. Oil-Quench (Lubrication and cooling) of the mechanical seals
 - b. Detection of seal failures
 - c. Buffer zone to the sealed timing gear
7. Oil drain of gearbox and intermediate chamber shall be easily accessible with side mounted drain screw. Oil drain under the pump is not acceptable.
8. The rotor/shaft connection shall be oil-lubricated fed by an intermediate chamber and shall not come in contact with the pumped fluid.

C. System and Fluid Conditions

1. Fluid Name: Sludge

2. Solids Content:..... 1% to 2%
3. Capacity: 5 to 50 m³/hour
4. Discharge Pressure:..... 15 to 20 psi
5. Suction Condition: Flooded
6. Temperature: Ambient
7. pH Value:..... Neutral
8. Specific Gravity: 1.0
9. Duty: Continuous

D. Pump Unit

1. Drive Type: Geared motor with flexible coupling
2. Drive Configuration: In line
3. Motor Power: 5 HP
4. Pump Speed: 123 to 279 rpm
5. Suction Flange: 3 inch
6. Discharge Flange: 3 inch

E. Pump Construction

1. The pump casing shall be manufactured in a single block construction (Cast iron ASTM A48 Class 40, Brinell hardness of 264 BHN). Multiple piece design pump casings held together by screw connections shall not be acceptable.
2. The rear of the pump casing and the front cover shall be protected with replaceable wear plates with a hardness of 550 BHN. The front cover protection plate shall be reversible.
3. The quick release cover shall be held in place by four eye nuts. The stationary threaded studs shall keep the front cover on the same level as the pump casing in the process of opening the pump for easy handling.
4. Rotors shall be dual-lobe design and shall consist of a non-sludge-wetted cast iron core entirely coated with abrasion-resistant Buna-N. Stacking of lobes is not acceptable. Rotors shall be keyed to the shaft and secured with one screw to a cylindrical thread inside the shaft. The cast iron core of the rotor shall be equipped with a female thread to enable the removal of the rotor from the shaft with ease. Rotor/shaft designs with a cover disc and/or spring washers shall not be acceptable.
5. The shafts shall be non-sludge-wetted. The rotor/shaft connection shall be lubricated with quench fluid of the intermediate chamber. The shafts shall be timed in their rotation by straight cut timing gears running in a separate oil chamber, which also contains the ball and roller bearings for each shaft. Sludge wetted rotor/shaft connections are not acceptable. The shafts shall be constructed from AISI 4140 carbon steel.
6. The pumps shall be fitted with maintenance free, quenched mechanical seals with silicon carbide seal faces. The seals shall be operating in a common oil-filled intermediate chamber (Quench for lubrication and cooling). Purge systems for the seals are not acceptable. The

rotating holding bush shall be locked in a fixed radial position by a keyway that also holds the rotor in place. Seal designs that open during rotor replacement are not acceptable. No sleeves shall be necessary for the mechanical seal set up. Design of the pump shall allow removal and replacement of the seal via the front cover.

7. Bearings and timing gear shall be located in a common oil-filled cast iron gearbox, fitted with a built-in sight glass to monitor oil level. The timing gear shall maintain non-contact between the rotors. Bearing life to be designed for L-10 bearing life rating of 100,000 hours at design conditions.
8. Suction and discharge connections from galvanized steel shall be ANSI 150 lb flanges.
9. Pump and drive fitted on common base, made from galvanized steel.

F. Motors

1. Each unit shall consist of a pump with a gear reducer and 1,800 rpm premium efficiency electric motor.
2. The motor shall be 3 phase, 60 Hz, 460 V, with a 1.15 service factor and Class F Insulation.
3. All motors shall be built in accordance with latest NEMA, IEEE, ANSI and AFBMA standards where applicable.

G. Control

1. The Rotary Press shall be fed by an adequate proportion of flow and pressure, resulting in a uniform feed of sludge and diluted polymer to the Rotary Press.
2. The feed sludge is pumped to the flocculator as to maintain a constant pressure at its inlet. To accomplish this, the rotating speed of the feed sludge pump shall be adjusted according to the internal pressure of the flocculator as to maintain the pressure close to the set value. For this reason, the sludge pump shall be VFD controlled by the Rotary Press control panel.
 - a. Variable Frequency Drive (VFD): Variable frequency drive shall be used to control the speed of the sludge pump. VFD shall have overload protection and ramp regulation capability. Configuration and programming shall be done via a keypad. Run command shall be with dry contact and the speed shall be with 4-20 mA. As per Owner requirement, VFDs shall be powered with 480 or 575 VAC, 3 phase, 60 Hz. Output shall be 480 or 575 VAC, 0 to 60 Hz. VFD rating 5 HP and more shall be flange mounted type, in order to keep the heat outside the control cabinet. VFD shall be the following.
 - 1) Quantity:.....One (1) for each sludge pump
 - 2) Power: 5 HP
 - 3) Company: Allen-Bradley
 - 4) Model PowerFlex 40

2.09 MISCELLANEOUS

A. Painting and Protection

1. For equipment and steel piping:

- a. Surface preparation
 - 1) Near white blast cleaning according to SSPC-SP10 for the equipment
 - 2) Pickling SSPC-SP8 for the piping.
- b. Primer
 - 1) Type: Epoxy Resin (high build) Carboguard 893
 - 2) Note According to the ONGC-1 GP165A Standard(US equivalent Standard SSPC Paint No. 22)
 - 3) Dry thickness:.....6 mils (152 μ m) minimum
- c. Finish coat
 - 1) Type: Polyurethane
 - 2) Color: Glass Shield Blue # 2862044 Carbothane 134 HG blue
 - 3) Dry thickness:.....Two (2) of 1.5 mils by layer, total thickness of 3 mils minimum
 - 4) Total system thickness: ...9 mils (229 μ m) minimum
2. For all wetted parts:
 - a. Surface preparation
 - 1) Near white blast cleaning according to SSPC-SP10
 - b. Primer
 - 1) Type: Epoxy Resin (high build) Plasite #7122
 - 2) Note:.....According to the ONGC-1 GP165A Standard(US equivalent Standard SSPC-Paint No. 22)
 - 3) Dry thickness:.....9 mils (229 μ m) minimum
3. The surfaces in contact with feed sludge, filtrates and cake shall be painted except when those surfaces are made out of stainless steel or polymer-based product.

B. Materials

1. The steel used in the construction shall meet the following standards.
 - a. Tubing: CSA G40.21 - 44W (US equivalent ASTM A 500)
 - b. Structural shape: CSA G40.21 - 44W (US equivalent ASTM A 572)
 - c. Plate: CSA G40.21 - 44W (US equivalent ASTM A 36)
 - d. Sheet: ASTM A569
 - e. Shaft: AISI-1045
 - f. Stainless steel: AISI 304, AISI 316
2. Special maintenance tools shall be supplied. Those tools shall include a shaft torque wrench and lifting bolt for wheel and housing. The special maintenance tools shall be delivered into a tool box.

C. Fasteners

1. All fasteners to be used shall be made according the ANSI/ASME B18 standards.
2. Except if otherwise noted, ASTM F738M stainless steel bolts and ASTM F836M stainless steel nuts (property class A1-50 for both, or equal) shall be used for all assemblies.
 - a. Channel housings
 - b. Gland covers to channel housing
 - c. Filtrate collector to channel housing
 - d. Channel sludge inlet to the channel housing
 - e. Anti-rotation plate to the channel housing
 - f. Channel housings to outer spacers
 - g. Filtration wheels to the inner spacer
 - h. Scraper blades to outer spacer
 - i. Actuator support to the channel assembly
 - j. Lifting devices to the channels
 - k. Interior bushing to the gland cover hub
 - l. Washwater system support to gland cover
 - m. Speed reducer to reducer base
 - n. Deflector
 - o. Actuator support
 - p. Speed reducer output shaft to its cap plate
 - q. Identification plates
 - r. Motor bell housing to the speed reducer input
 - s. Input and output flocculator piping
 - t. Flocculator

D. Welding

1. All the welding shall be performed under the AWS Standard, CSA Standard, or equal.

E. Noise Level

1. The noise level of each of the equipment shall not exceed 75 dBA measured at 3 feet (1 meter) from the source.

F. Interchangeability

1. All parts from the Rotary Press or from channel shall be interchangeable with another.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Conveyors shall be set upon level, fully grout foundations so that connecting flanges, screwed connection, or flexible connection shall meet without strain or distortion.

3.02 TESTING

- A. All screw conveyor equipment shall be fully assembled and operated prior to shipment to the job site. Operation shall be smooth, free of vibration or unwarranted noise, or unwarranted high starting or no-load running amperage draw.

3.03 FIELD PAINTING

- A. Stainless steel components shall not be painted.
- B. Surface preparation for painting according to SSPC-SP 6
 - 1. Primer
 - a. Type: Epoxy Resin (high build)Note: According to the ONGC-1 GP165A Standard (US equivalent Standard SSPC Paint No. 22)
 - b. Dry thickness: 6 mils minimum
 - 2. Finish coat
 - a. Type: Polyurethane
 - b. Color: Glass Shield Blue # 2862044
 - c. Dry thickness: Two (2) of 1.5 mils by layer, total thickness of 3 mils minimum.
 - d. Total system thickness: 9 mils minimum

3.04 SCHEDULES

A. Screw Conveyor Schedule

Identifier	Receiving Conveyor
Conveyor Type	Horizontal, Mono-Directional, Shaftless
Material handle	Cake from discharge of Rotary Press
Mass Flow Capacity	1.5 wet ton/hour
Loading at nominal capacity	45%
Material density	45 lbs / cubic feet
Temperature	40°F to 100°F
Flight nominal diameter	9-inches diameter
Flight Pitch	9-inches pitch
Flight section	2-1/2" X 3/4"
Flight material	High strength chrome alloy steel, 200 Brinell minimum
Flight diameter tolerance	±0 to 1/4"

Flight pitch tolerance	±1/4"
Conveyor nominal Length	13' - 7'' ft
Conveyor slope	0 degrees
Trough body	U-Trough, 304 stainless steel, 11 gauge
Trough cover	304 stainless steel, 12 gauge
Trough end flanges	304 stainless steel, 3/8 inch thick
Trough end plates	304 stainless steel, 1/4 inch thick
Discharges chutes	304 stainless steel, 1/8 inch thick
Support	304 stainless steel, 5/16 inch thick
Liner	UHMW, 3/8 inch thick
Inlet	Six (6)
Inlet type	Inlet cake chutes from Rotary Press
Outlet	One (1)
Outlet type	To Inclined Conveyor
Gear reducer Manufacturer	Nord Gear
Gear reducer model	SK2282 SCP
Power	1 HP 480V/60Hz/3ph
Output speed	24 rpm
Special Requirements	2-inch drain Screw Conveyor Package gear motor flange
Identifier	Inclined Conveyor
Conveyor Type	Inclined, Mono-Directional, Shaftless
Material handle	Cake from discharge of Rotary Press
Mass Flow Capacity	1.5 wet ton/hour
Loading at nominal capacity	45%
Material density	45 lbs / cubic feet
Temperature	40°F to 100°F
Flight diameter	9-inches diameter
Flight Pitch	5-inches pitch
Flight section	External section of 2 1/2" X 3/4" and internal section of 1" X 1/2"
Flight material	High strength chrome alloy steel, 200 Brinell minimum
Flight diameter tolerance	±0 to 1/4"
Flight pitch tolerance	±1/4"
Conveyor nominal Length	22'-2''
Conveyor slope	30 degrees
Trough body	Tubular O-Trough 304 stainless steel, 10 gauge
Trough cover	304 stainless steel, 12 gauge
Trough end flanges	304 stainless steel, 3/8 inches thick
Trough end plates	304 stainless steel, 1/4 inch thick
Discharges chutes	304 stainless steel, 1/8 inch thick
Support	304 stainless steel, 5/16" thick
Liner	UHMW, 3/8 inch thick
Inlet	One (1)
Inlet type	Chute from Receiving Conveyor
Outlet	One (1)
Outlet type	To Distributing Conveyor

Gear reducer Manufacturer	Nord Gear
Gear reducer model	SK2282 SCP
Power	5 HP 480V/60Hz/3ph
Output speed	53 rpm
Special Requirements	2-inch drain Screw Conveyor Package gear motor flange
Identifier	Distributing Conveyor
Conveyor Type	Horizontal, Mono-Directional, Shaftless
Material handle	Cake from discharge of Rotary Press
Mass Flow Capacity	1.5 wet ton/hour
Loading at nominal capacity	45%
Material density	45 lbs / cubic feet
Temperature	40°F to 100°F
Flight diameter	9-inches diameter
Flight Pitch	9-inches pitch
Flight section	2 ½" X ¾"
Flight material	High strength chrome alloy steel, 200 Brinell minimum
Flight diameter tolerance	±0 to 1/4"
Flight pitch tolerance	±1/4"
Conveyor nominal Length	15'-11"
Conveyor slope	0 degrees
Trough body	U-Trough, 304 stainless steel, 11 gauge
Trough cover	304 stainless steel, 12 gauge
Trough end flanges	304 stainless steel, 3/8 inch thick
Trough end plates	304 stainless steel, 1/4 inch thick
Discharges chutes	304 stainless steel, 1/8 inch thick
Support	304 stainless steel, 5/16 inch thick
Liner	UHMW, 3/8 inch thick
Inlet	One (1)
Inlet type	Chute from Inclined Conveyor
Outlet	One (1) Pneumatic slide gate and two (2) Standard Outlets
Outlet type	To cake bin
Gearmotor Manufacturer	Nord Gear
Gearmotor model	SK2282 SCP
Power	1 HP 480V/60Hz/3ph
Output speed	24 rpm
Special Requirements	2-inch drain Screw Conveyor Package gear motor flange

END OF SECTION